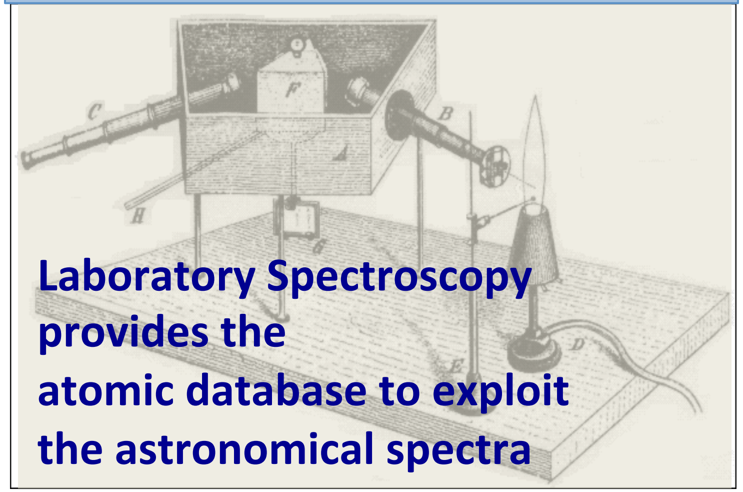
Leone Francesco
Plasma@Lab4Space + NERTIMP

Laboratory-Plasma Spectropolarimetry for Astrophysics

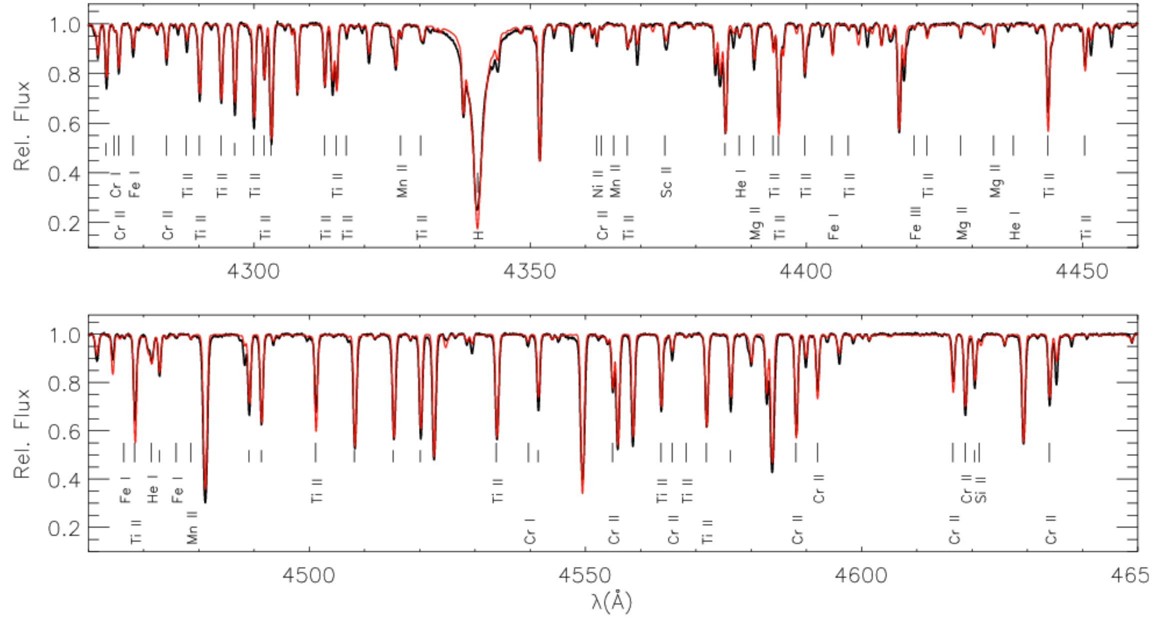
is an experimental support to
High Energy Astrophysics

by providing laboratory atomic parameters
for plasma diagnostics

Explanatory Statment

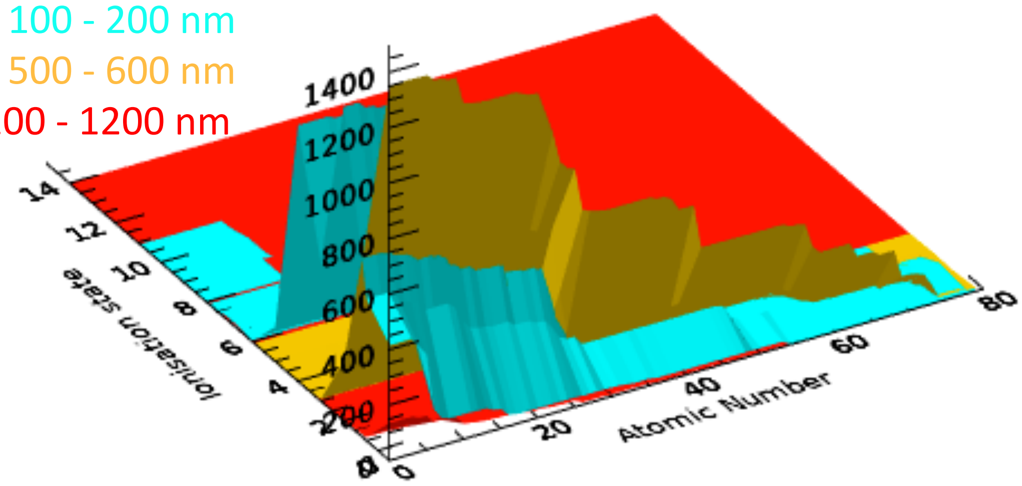


Laboratory Spectroscopy provides the atomic database to exploit the astronomical spectra



From NIST
Number of experimentally observed lines
vs the Atomic Number
vs the Ionisation state
in the range

100 - 200 nm
500 - 600 nm
1100 - 1200 nm



Experimental transitions are

- reasonably known for neutrals or low ionisation states up to iron-peak elements in the 200-1000 nm range
- poorely known for high-Z elements at any wavelengths
- missing for highly-ionised-species

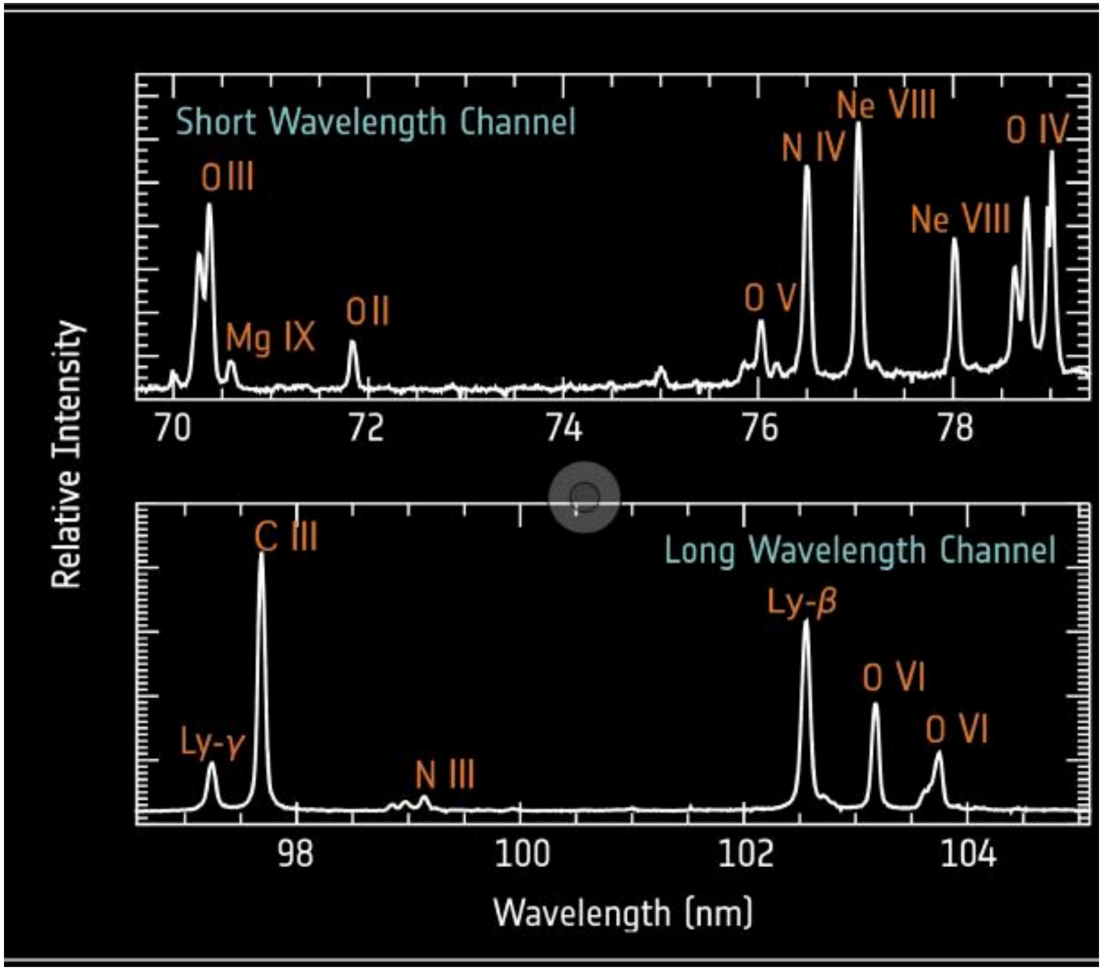
Current atomic database is satisfactory for a low-temperature plasma of light-atoms (e.g. stellar atmospheres, up to iron-peak) if observed in the UV and Visible range

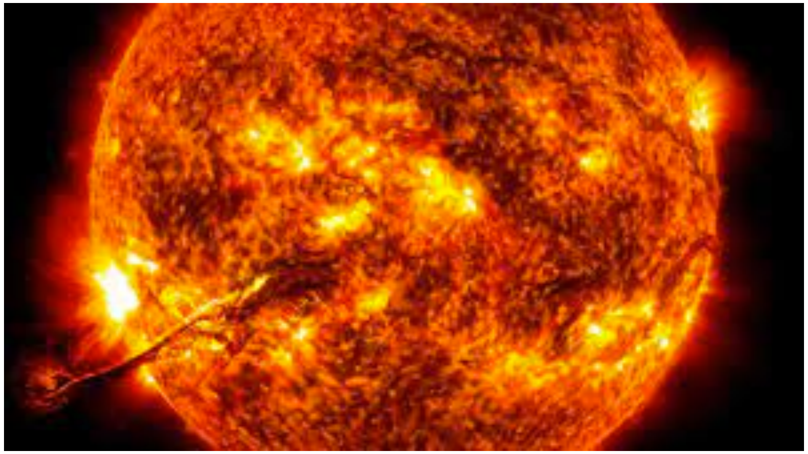
High Energy Astrophysics requires experimental atomic-data for

- **high-Z atoms**
- **highly-ionised species**
- **from Vacuum-UV to NIR**

INAF is involved in Solar Orbiter (1.5 G€)

SPectral **I**maging of the **C**oronal **E**nvironment





NIST

O III-VI

476 Ritz wavelengths

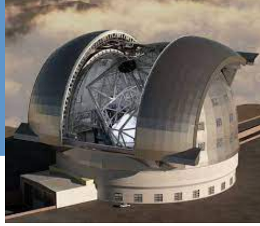
30 observed lines

Fe III-XXV

2099 Ritz wavelengths

78 observed lines

INAF is involved in ELT (1.5 G€)



The unknown UV lines will affect
ANDES (R = 100,000; 0.35-2.4μm) Spectroscopy of high-z objects

ANDES
R = 25000
T_{exp} = 3 h
S/N = 40

GRB111008A at z = 5

```
g' > 24.0,
r' = 22.6 +/- 0.1
i' = 20.9 +/- 0.1
z' = 19.9 +/- 0.1
```

GMOS@Gemini-South
R = 870

THE ASTROPHYSICAL JOURNAL, 785:150 (12pp), 2014 April 20 SPARRE ET AL.

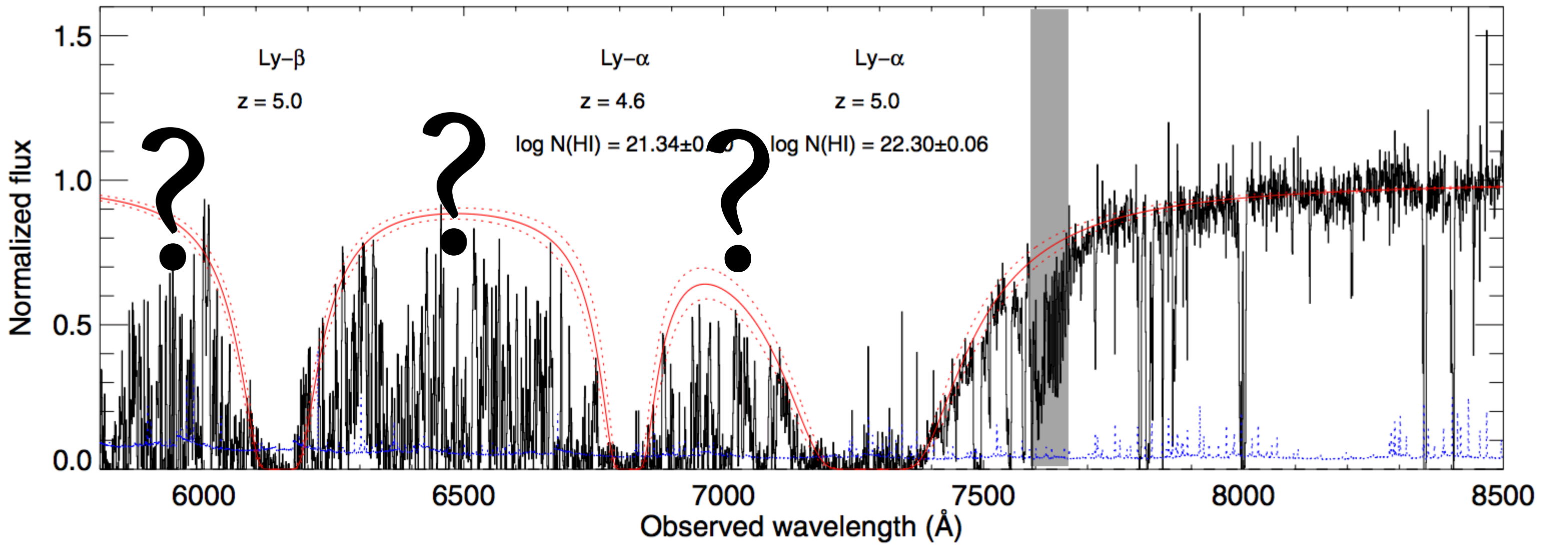


Figure 1. Excerpt of the VIS spectrum showing absorption from Lyα and Lyβ of the host galaxy of GRB 111008A ($z = 5.0$) and Lyα of the strong intervening system at $z = 4.6$. The red line displays a Voigt-profile fit to the DLAs Lyα and Lyβ lines. The dashed line shows the 1σ error on the fit result, and the dotted line shows the error spectrum. The shaded gray indicates a region with strong telluric contamination.

And, ELT Spectroscopy will supply evidence of *r*-process in neutron star mergers only if an atomic database of highly ionised heavy-elements is created in the UV-NIR range

The Astrophysical Journal Letters, 848:L19 (7pp), 2017 October 20
https://doi.org/10.3847/2041-8213/aa905c

CrossMark

The Electromagnetic Counterpart of the Binary Neutron Star Merger LIGO/Virgo GW170817. IV. Detection of Near-infrared Signatures of *r*-process Nucleosynthesis with Gemini-South

The Astrophysical Journal Letters, 848:L19 (7pp), 2017 October 20

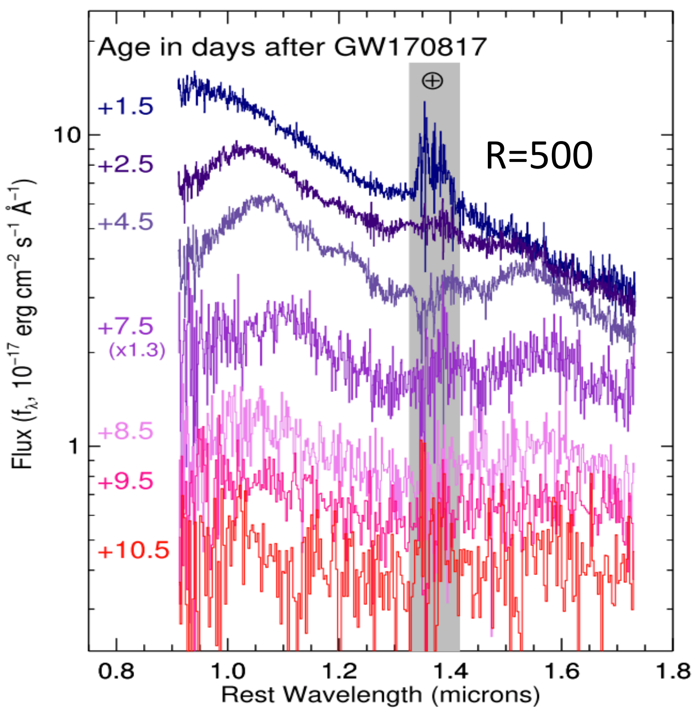
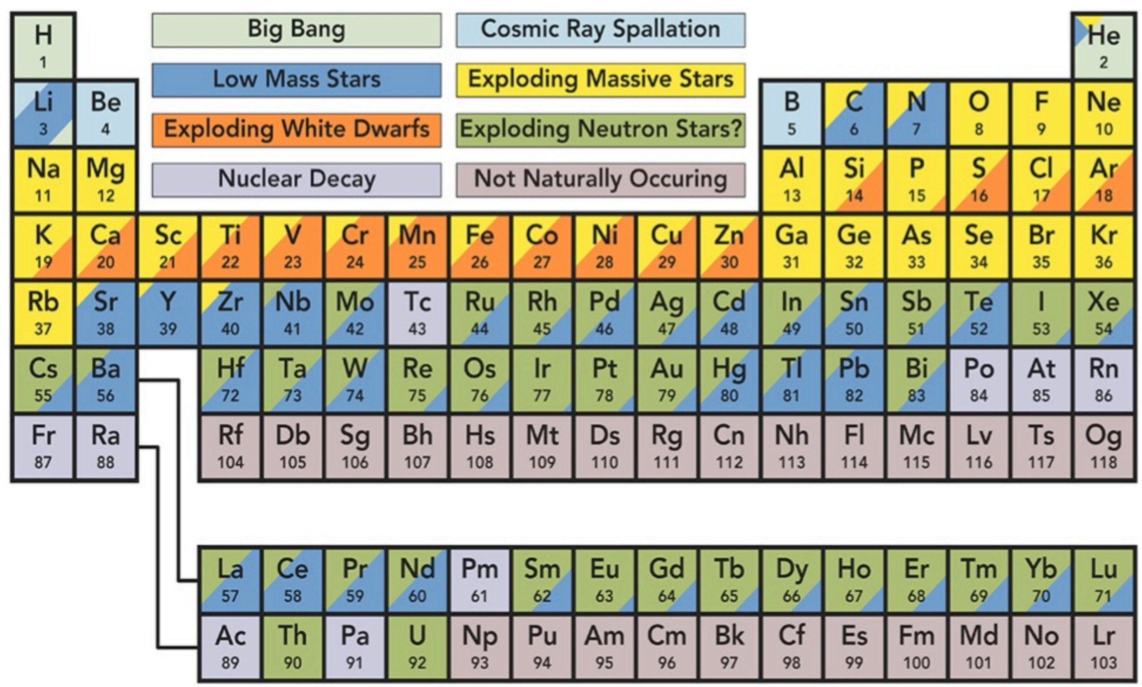
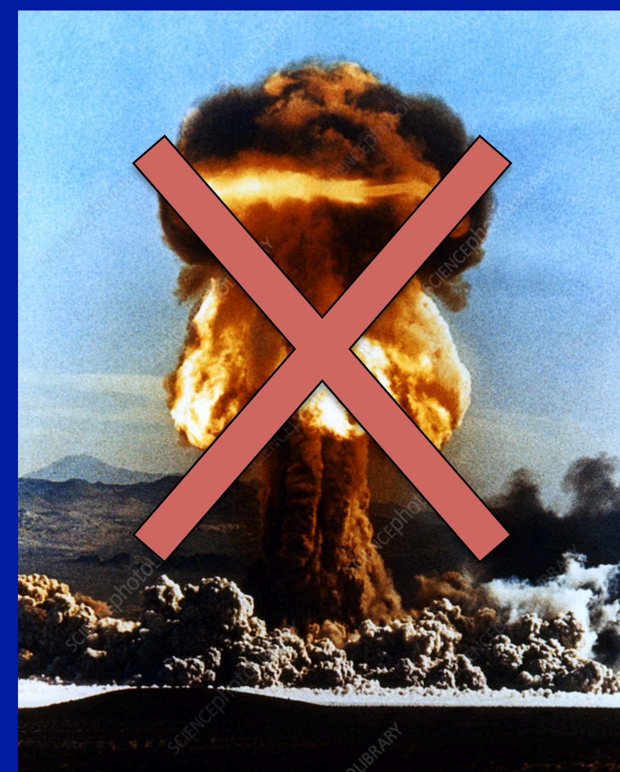
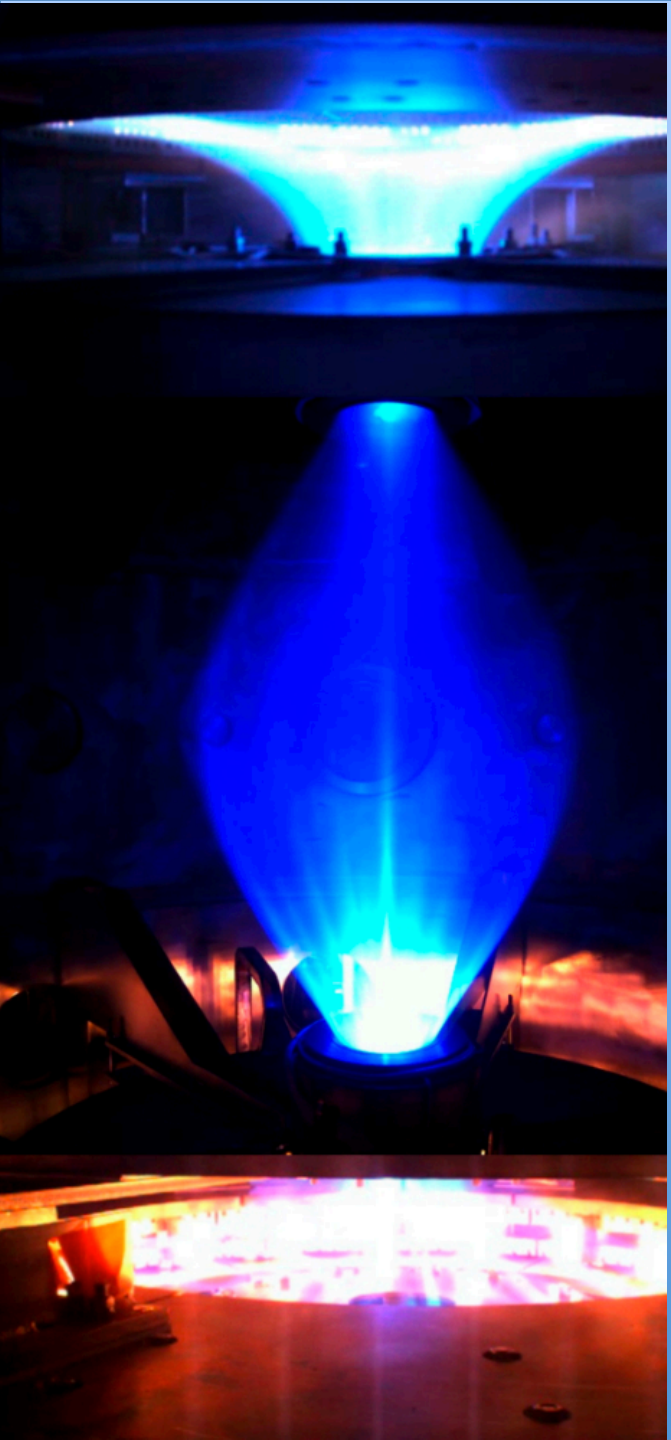


Figure 1. NIR spectral sequence of GW170817 from Gemini-South. Each epoch is labeled with its age in days after the GW trigger. The spectra have been de-redshifted, corrected for Galactic extinction, and scaled to match the *H* photometry (Cowperthwaite et al. 2017). The +7.5 days spectrum has been scaled by an additional factor of 1.3 for presentation purposes. The first three spectra are presented unbinned, but the later ones are binned by increasingly larger factors. The region of strong telluric absorption between *J*- and *H*-bands is indicated by the gray box.



The lack of experimental atomic parameters for highly ionised species is historically due to the difficulty in reaching million-degree temperatures <u>under controlled conditions</u>





Todays things have changed million-degree plasmas are generated in laboratory

We started

Plasma@Lab4Space

a program of

laboratory-plasma spectropolarimetry

to build an

experimental atomic database

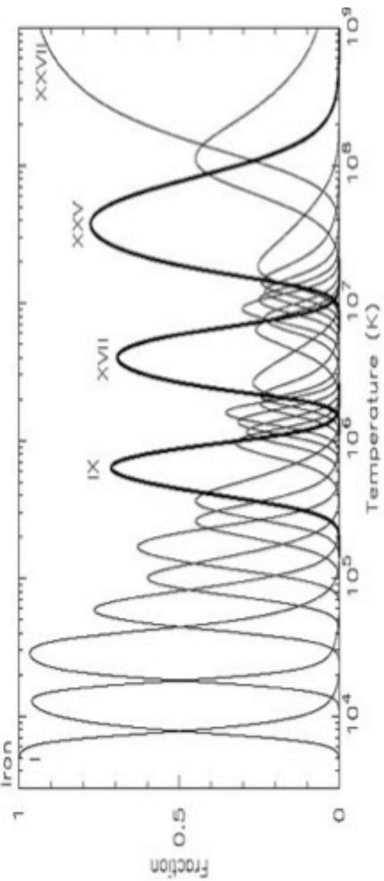
for spectral lines

of highly-ionised atoms

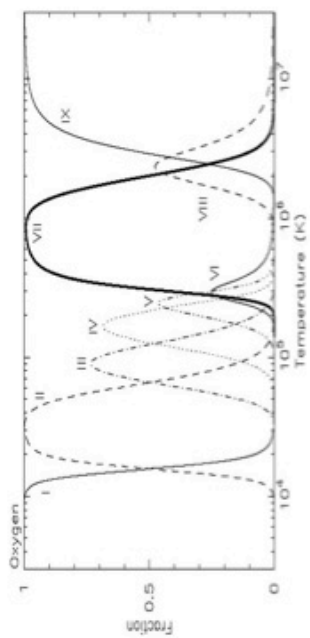
from Vacuum-UV to NIR

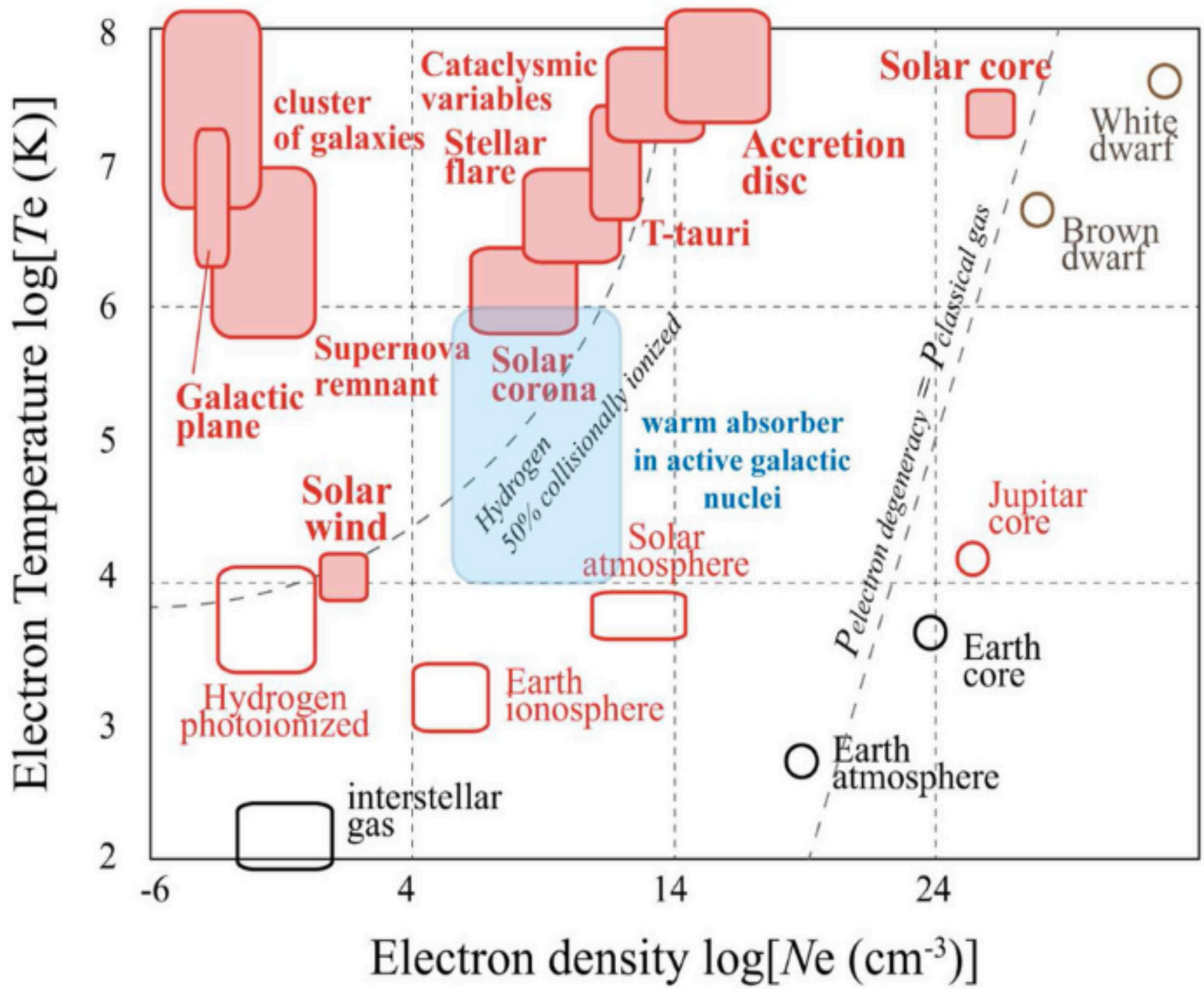
Plasma in Space

Iron



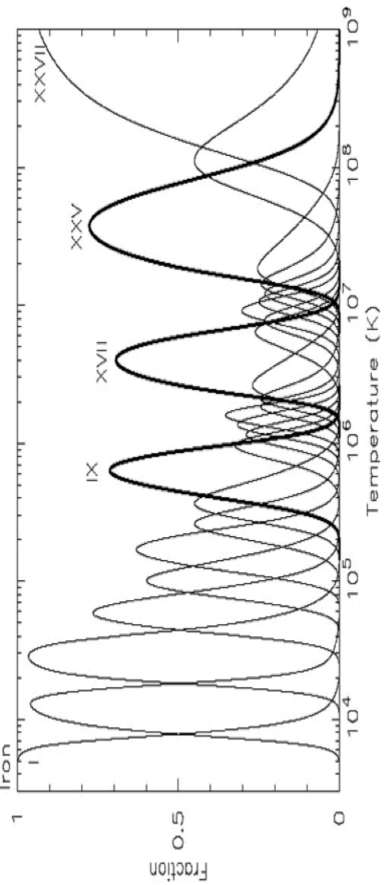
Oxygen



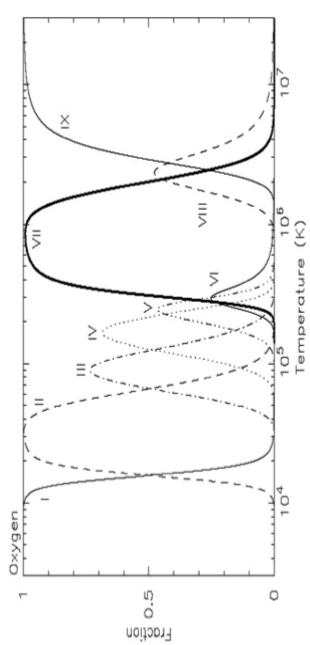


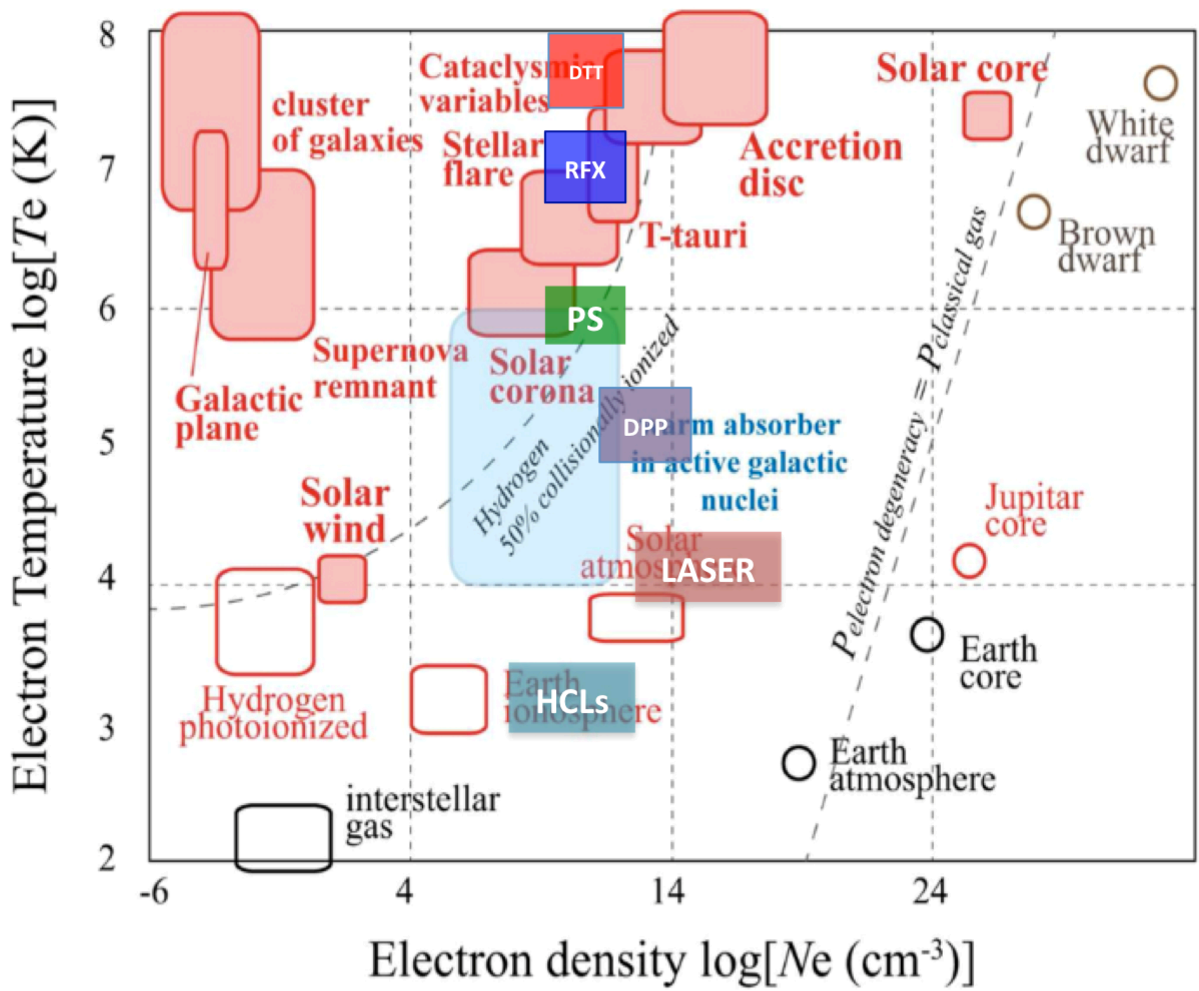
Plasma Sources

Iron

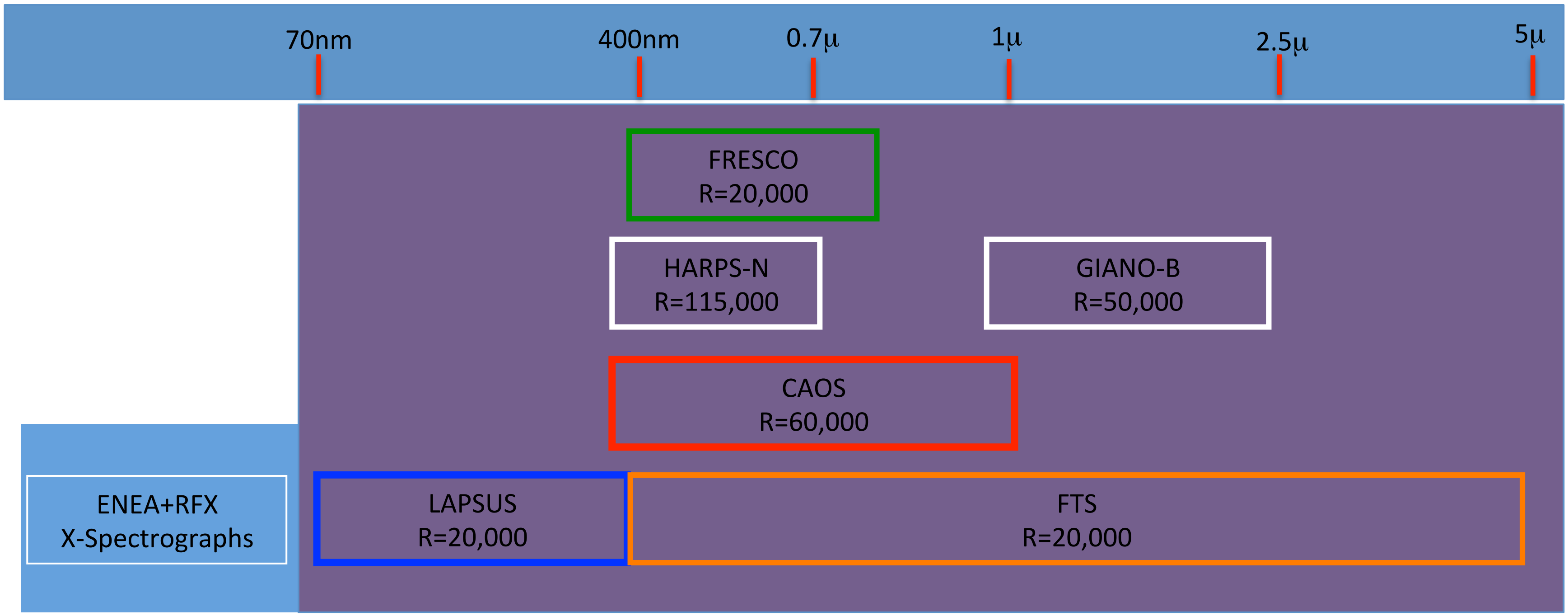


Oxygen





Spectrographs



In practise
Systematic spectroscopic measurements of plasma emissivity will be carried out **element-by-element at time**, to record line wavelengths and intensities

A Team of more than 38 people

INAF/Associato
New FTE
External

ENEA-Frascati-Fusion Division (MoU)

Gerarda Apruzzese (Spectroscopy)
Sarah Bollanti (DPP)
Francesca Bombarda (X-ray)
Paolo Buratti (Proto-Sphera)
Alessandro Cardinali (RF emission)
Luca Mezi (DPP)
Francesco Flora (DPP)
Paolo Micozzi (Proto-Sphera)

RFX-Consortium

Lorella Carraro

Laser Plasma

Giuseppe Baratta

TNG People

Massimo Cecconi
Rosario Cosentino
Adriano Ghedina
Avet Harutyunyan

Laboratory Activity

Spectroscopy

Solar Physicists

Vincenzo Andretta
Marco Romoli
Daniele Spadaro

Stellar Atmospheres

Giuseppe Bono
Innocenza Busà
Giovanni Catanzaro
Antonio Frasca
Matteo Munari
Javier Alonso-Santiago

Atomic Physics

Giulio Del Zanna (Cambridge)
Enrico Landi (Michigan)
Marina Giarrusso (UniFi)
Joël Rosato (Marseille)
Martin Stift (Wiën)

Master Thesis
Salvatore Cabibbo (Charge Exchange)

Ph.D. Thesis
Claudio Ferrara (Plasma Spectroscopy)
Lorenzo Giustolisi (Stark-Zeeman line profiles)

Plasma Numerical Modeling

Vincenzo Antonuccio

Plasma Microwave Emission

Paolo Leto
Corrado Trigilio
Grazia Umana

INAF - TEAM

15. Team Summary

2022

15. Personale INAF coinvolto

Numero di partecipanti INAF al progetto: 26

Struttura	Nfte	N0	TI 22	TI 23	TI 24	TD 22	TD 23	TD 24	Nex	Extra
O.A. CATANIA	12	0	1.60	1.60	1.50	2.40	1.40	0.40	1	0.20
DIREZIONE SCIENTIFICA	0	0	0	0	0	0.00	0.00	0.00	1	0.10
IAPS ROMA	2	0	0	0	0	0.30	0.30	0.30	0	0.00
O.A. ARCETRI	1	0	0	0	0	0.10	0.10	0.10	0	0.00
O.A. CAPODIMONTE	1	0	0.10	0.10	0.10	0	0	0	0	0.00
O.A. ROMA	1	0	0	0	0	0.10	0.10	0.10	0	0.00
Totali	17	0	**1.70**	**1.70**	**1.60**	**2.90**	**1.90**	**0.90**	2	**0.30**

Team Summary

2021

15. Personale INAF coinvolto

Numero di partecipanti INAF al progetto: 25

Struttura	Nfte	N0	TI 21	TI 22	TI 23	TD 21	TD 22	TD 23	Nex	Extra
O.A. CATANIA	11	4	1.30	1.30	1.30	2.50	2.50	2.50	2	0.30
DIREZIONE SCIENTIFICA	0	5	0	0	0	0.00	0.00	0.00	1	0.10
IAPS ROMA	2	0	0	0	0	0.20	0.30	0.30	0	0.00
O.A. ARCETRI	0	1	0	0	0	0.00	0.00	0.00	0	0.00
O.A. CAPODIMONTE	0	1	0.00	0.00	0.00	0	0	0	0	0.00
O.A. ROMA	1	0	0	0	0	0.10	0.10	0.10	0	0.00
Totali	14	11	**1.30**	**1.30**	**1.30**	**2.80**	**2.90**	**2.90**	3	**0.40**

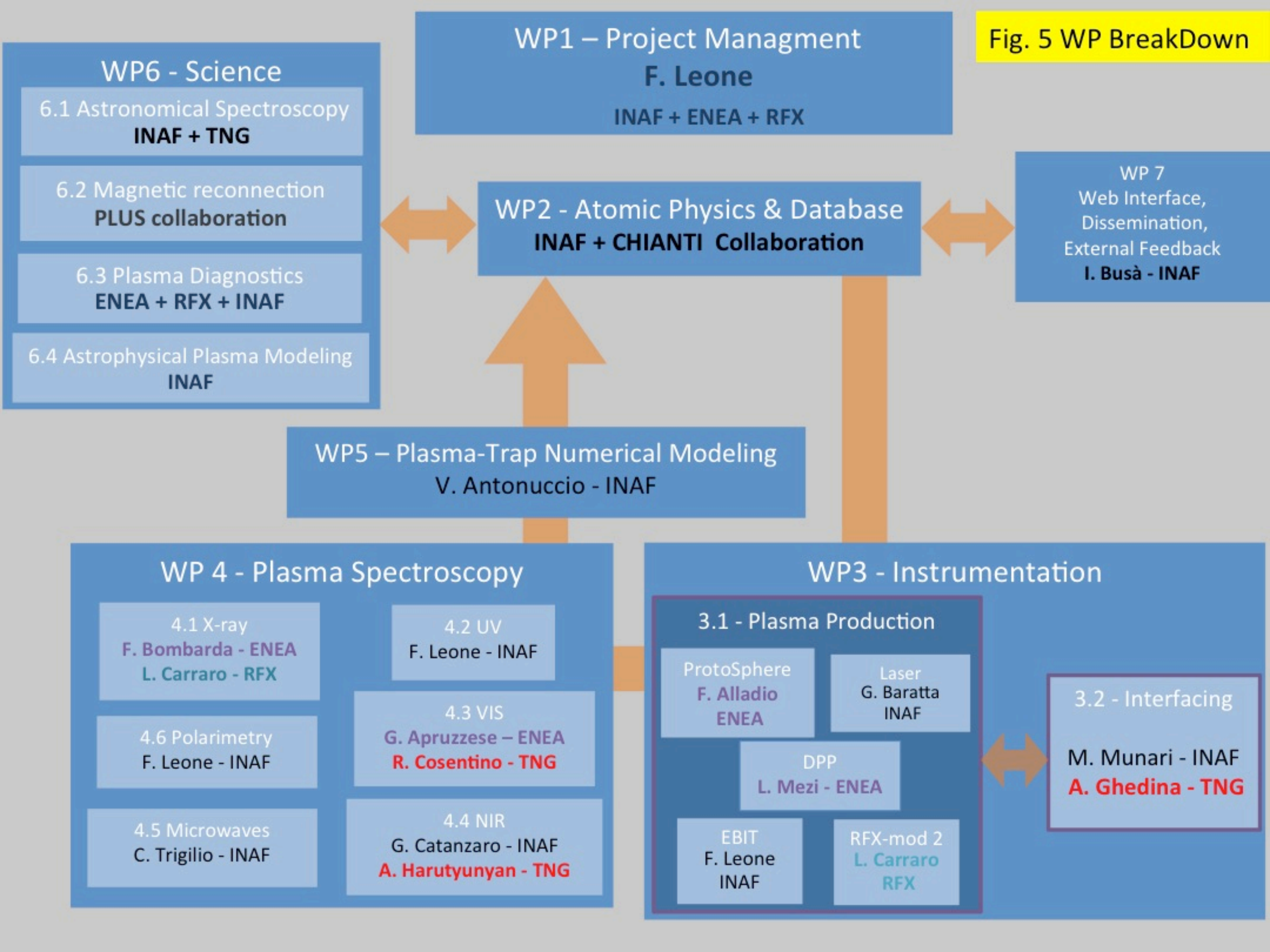
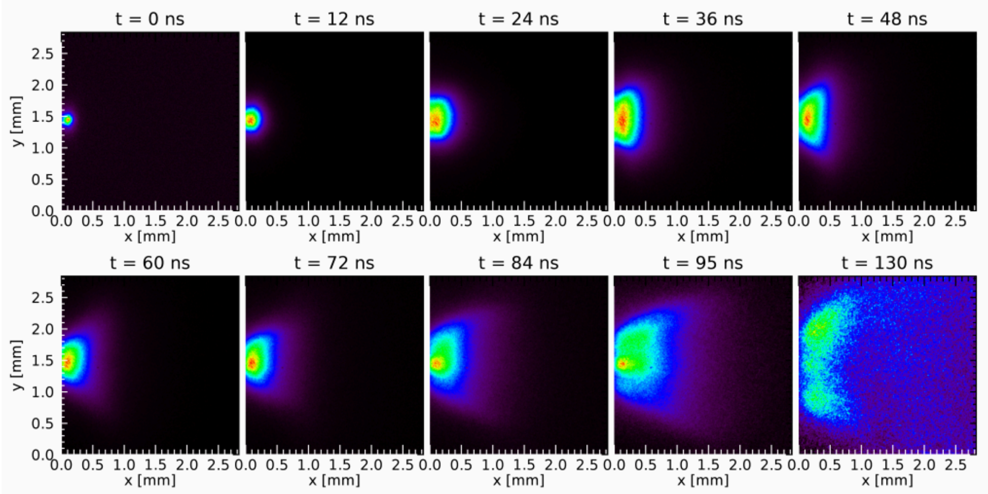


Fig. 5 WP BreakDown
WP1 – Project Managment
F. Leone
INAF + ENEA + RFX
WP6 - Science
6.1 Astronomical Spectroscopy
INAF + TNG
6.2 Magnetic reconnection
PLUS collaboration
6.3 Plasma Diagnostics
ENEA + RFX + INAF
6.4 Astrophysical Plasma Modeling
INAF
WP2 - Atomic Physics & Database
INAF + CHIANTI Collaboration
WP 7
Web Interface,
Dissemination,
External Feedback
I. Busà - INAF
WP5 – Plasma-Trap Numerical Modeling
V. Antonuccio - INAF
WP 4 - Plasma Spectroscopy
4.1 X-ray
F. Bombarda - ENEA
L. Carraro - RFX
4.2 UV
F. Leone - INAF
4.6 Polarimetry
F. Leone - INAF
4.3 VIS
G. Apruzzese – ENEA
R. Cosentino - TNG
4.5 Microwaves
C. Trigilio - INAF
4.4 NIR
G. Catanzaro - INAF
A. Harutyunyan - TNG
WP3 - Instrumentation
3.1 - Plasma Production
ProtoSphere
F. Alladio
ENEA
Laser
G. Baratta
INAF
DPP
L. Mezi - ENEA
EBIT
F. Leone
INAF
RFX-mod 2
L. Carraro
RFX
3.2 - Interfacing
M. Munari - INAF
A. Ghedina - TNG

Preparatory work and results

- **New Instrumentation**
- Experimental activities
- Theoretical tools

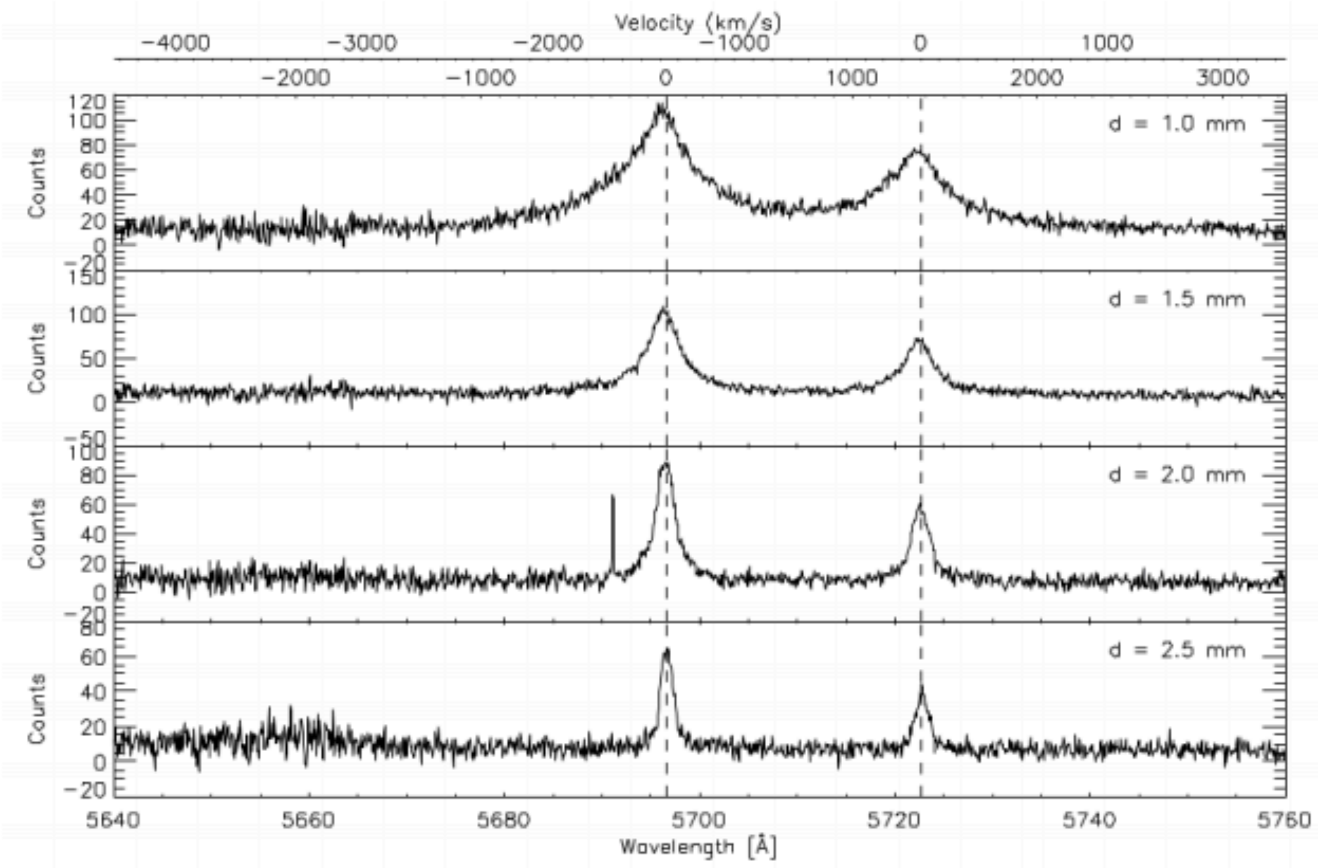
New optical interfaces for our Spectrographs



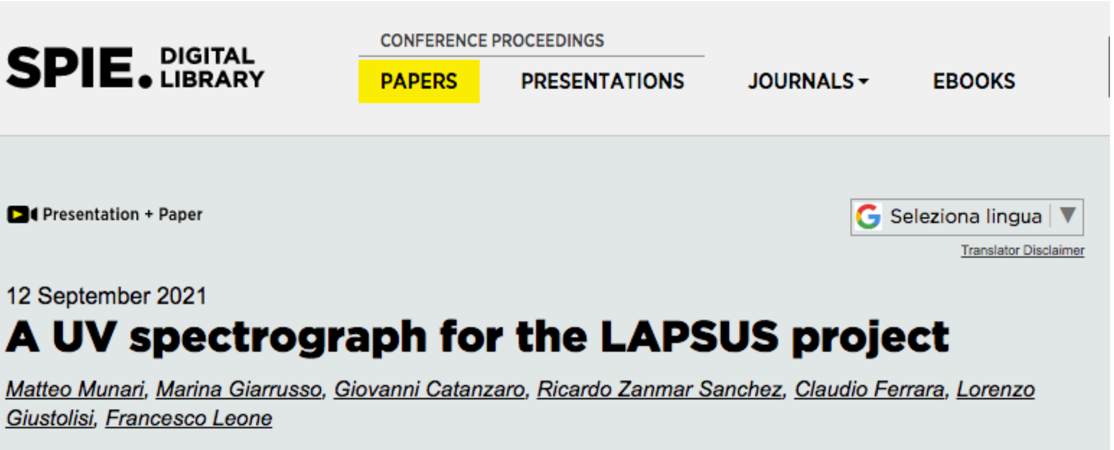
LASER-Produced Plasmas

(2019 tesi di laurea magistrale di Claudio Ferrara)

R=λ/Δλ=20 000



New Instrumentation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CONFERENCE PROCEEDINGS

PAPERS PRESENTATIONS JOURNALS EBOOKS

Presentation + Paper

Seleziona lingua

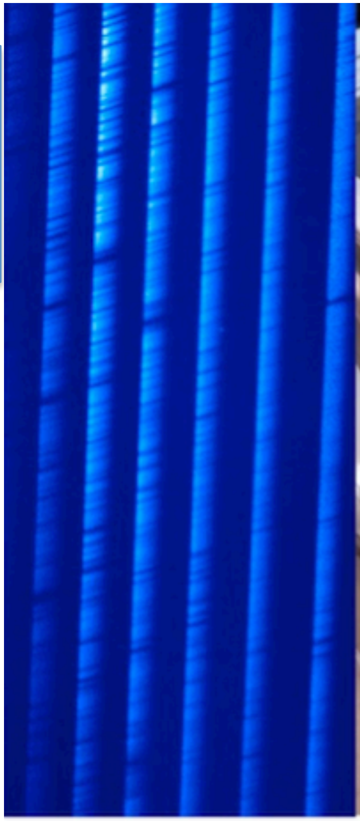
Translator Disclaimer

12 September 2021

A UV spectrograph for the LAPSUS project

Matteo Munari, Marina Giarrusso, Giovanni Catanzaro, Ricardo Zanmar Sanchez, Claudio Ferrara, Lorenzo Giustolisi, Francesco Leone

LAPSUS, an UV (70-400 nm, R=20 000) in-vacuum échelle spectrograph, funded by ASI-INAF n. 2018-16-HH.0 (PI M. Giarrusso) in 2020



Preparatory work and results

- New Instrumentation
- **Experimental activities**
- Theoretical tools

Systematics HCL-spectroscopy of Rare-Earths with CAOS (R = 60 000, 370-1000 nm)

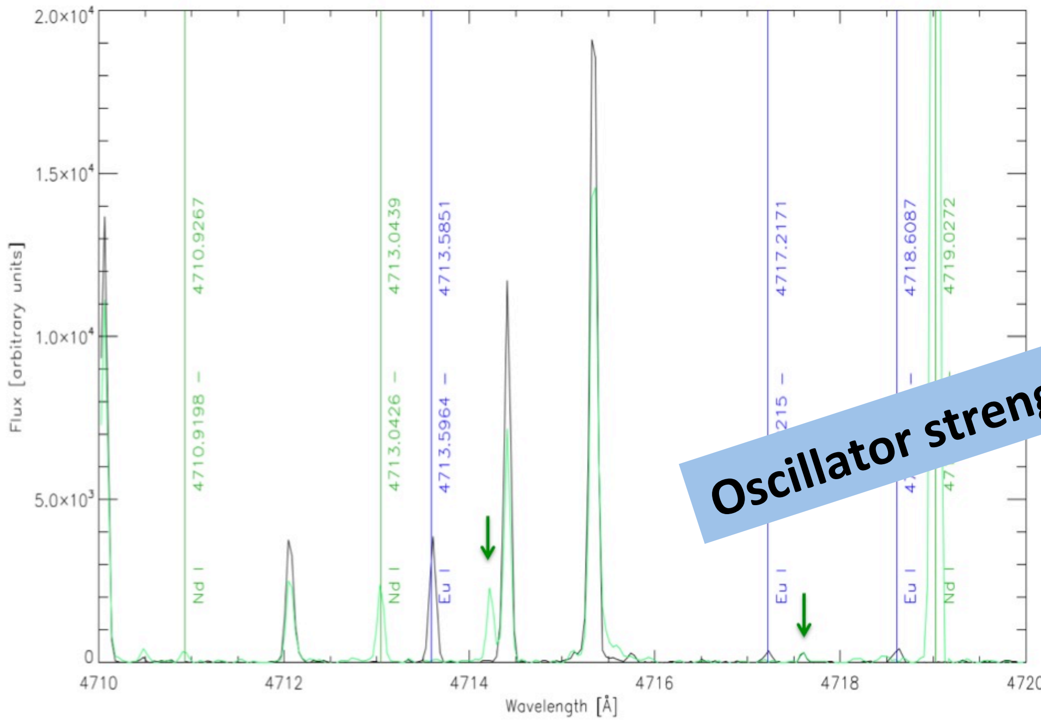


Figure 4. CAOS spectra of Eu-Ne (black) and Nd-Ne (green) Hollow-Cathode Lamps. NIST lines are marked with experimental and RItz wavelengths. In this small 10 Å chunk 2 unknown Nd lines are clearly visible.

Element	$N_{I-II,datab}$	$N_{I-II,new}$
Cs	801	6
Ba	1754	5
Pr	905	[illegible]
Nd	[illegible]	[illegible]
Sm	[illegible]	957
[illegible]	[illegible]	243
[illegible]	1296	183
Tb	478	2390
Dy	1110	272
Ho	407	383
Er	737	1335
Tm	5868	471
Yb	3330	353
Lu	186	10
Re	272	19
Os	336	123

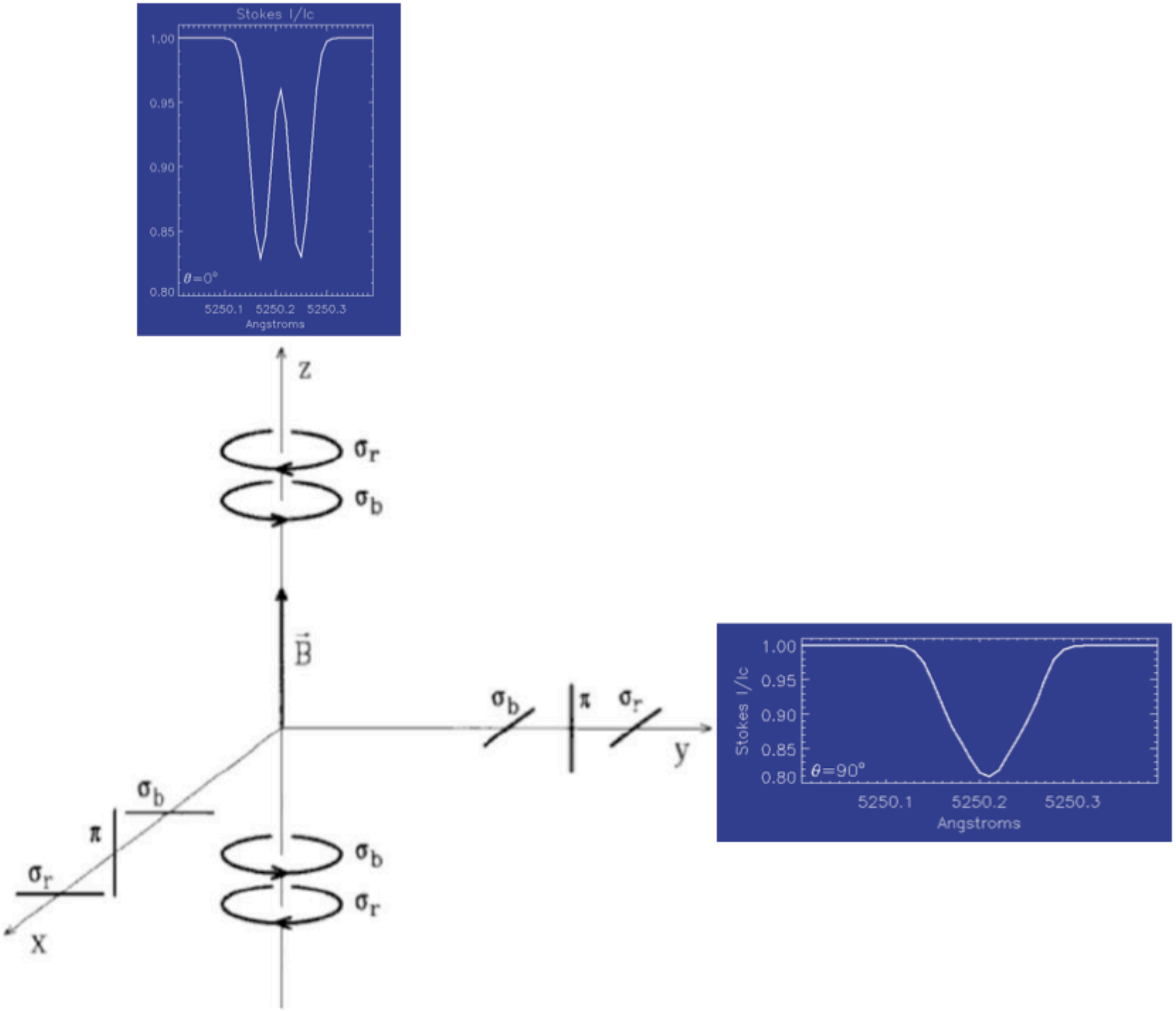
Oscillator strengths for new 8738 spectral lines

Preparatory work and results

- Hardware
- Experimental activities
- **Theoretical tools**

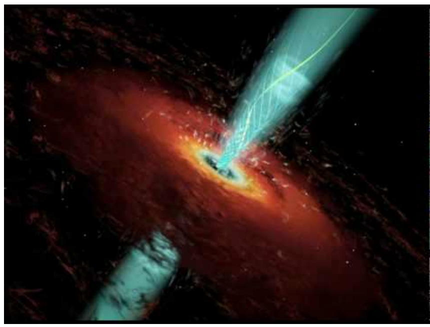
WHY SPECTROPOLARIMETRY ?

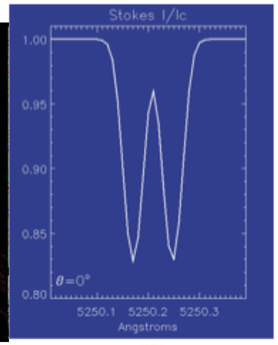
① Magnetised-Plasma spectral emission is not isotropic

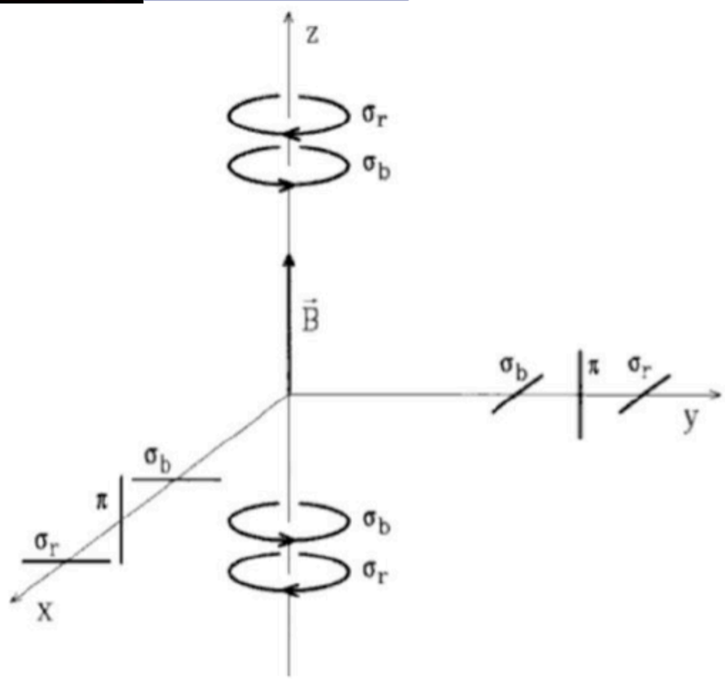


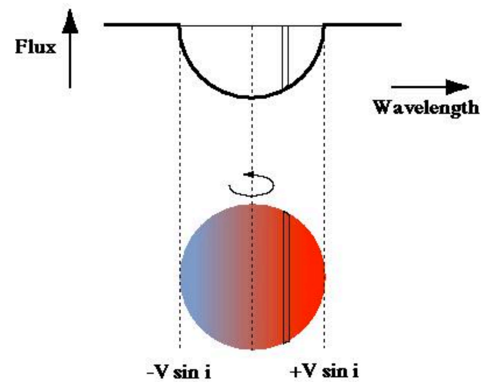
WHY SPECTROPOLARIMETRY ?

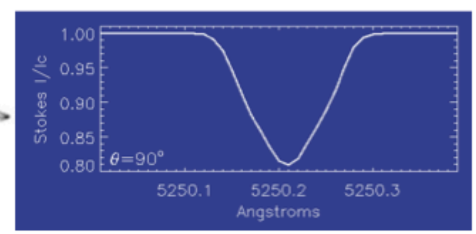
① Magnetised-Plasma spectral emission is not isotropic



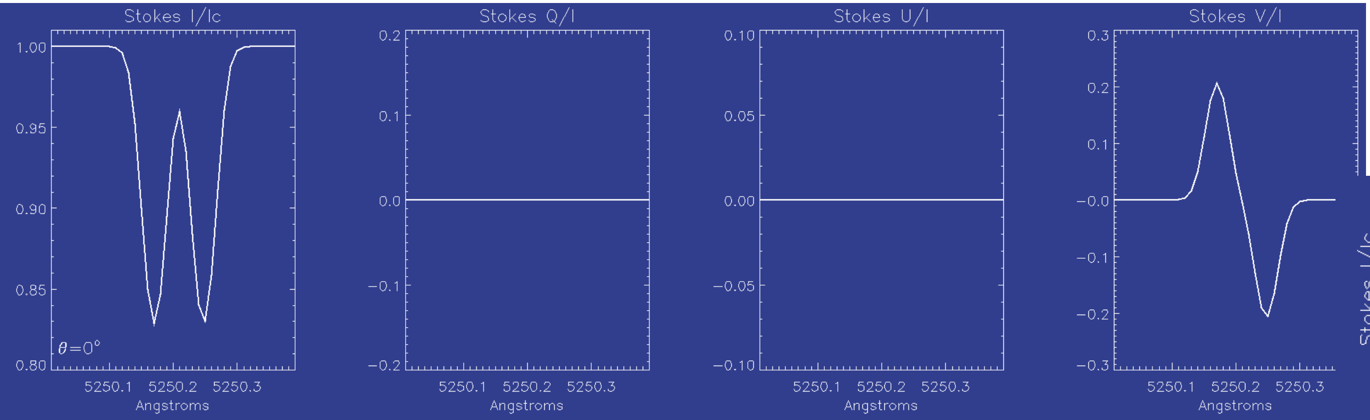


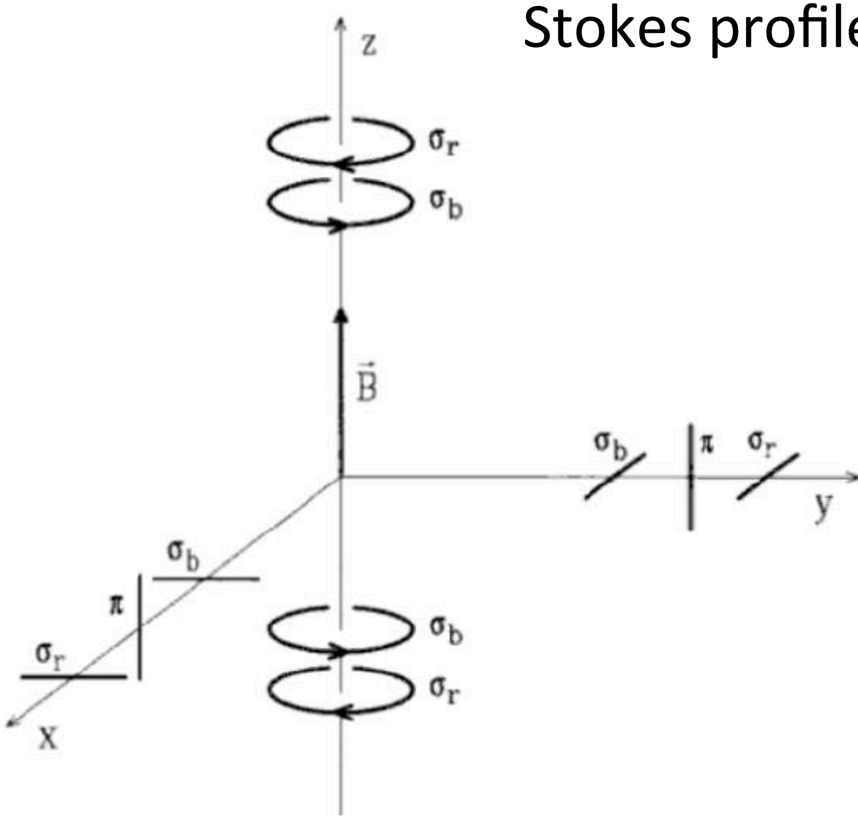


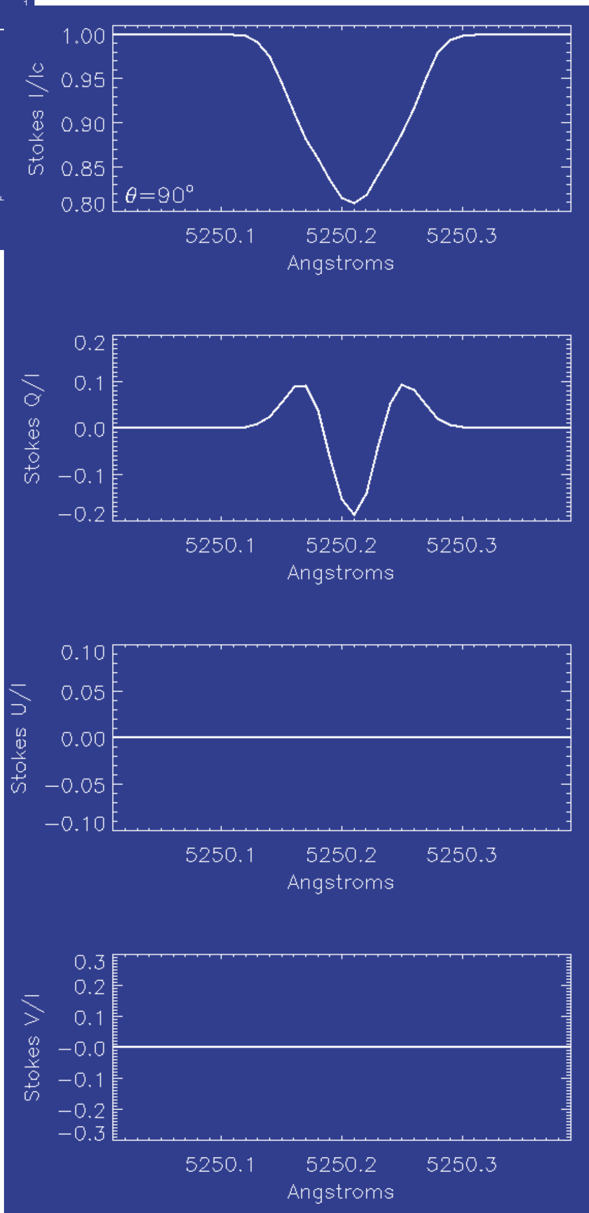




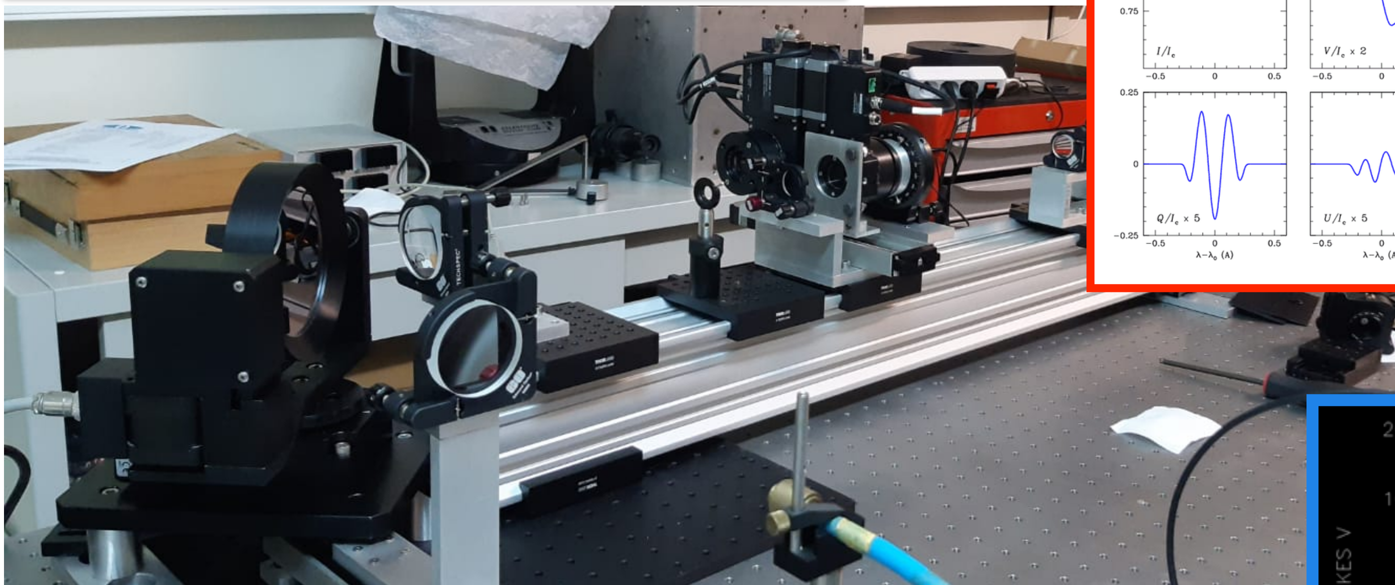
Stokes profiles

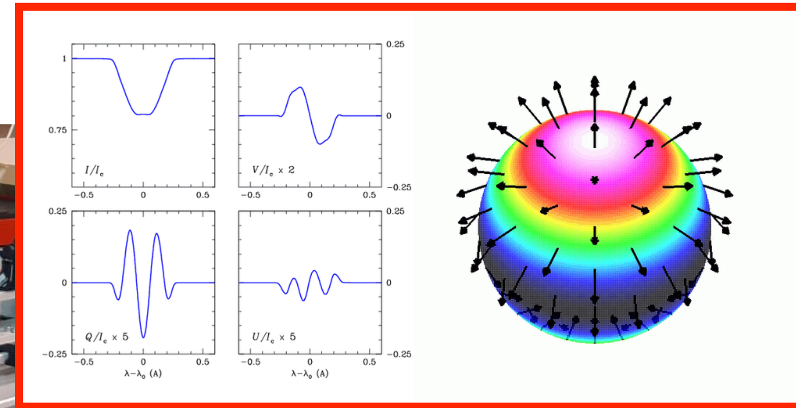


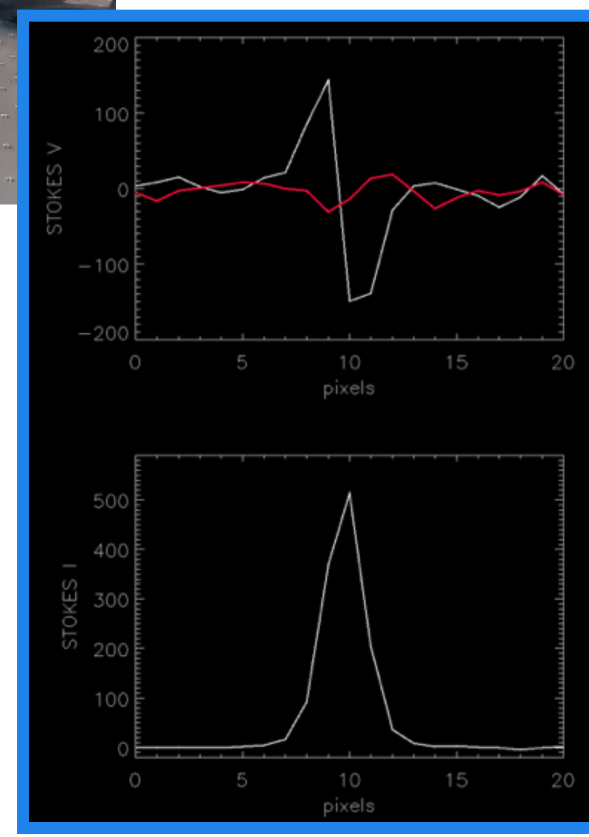




New Polarimetric units
with scanning capability
for a 3D mapping of magnetised plasmas







Stokes V profiles of HCL Th-Ne lines
(R=20000)

—— without B

—— with |B|≈ 100 G

WHY SPECTROPOLARIMETRY ?

① Magnetised-Plasma spectral emission is not isotropic

② Equivalent width depends on magnetic field strenght and orientation

A&A 398, 411–421 (2003)
DOI: 10.1051/0004-6361:20021605

Astronomy & Astrophysics

Magnetic intensification of spectral lines

M. J. Stift[1] and F. Leone[2]

No Field

Wrong Abundance

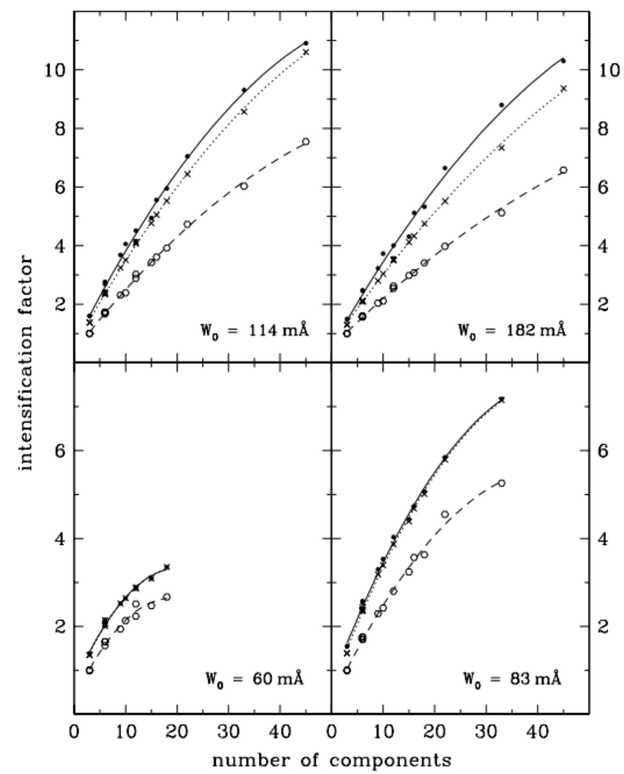
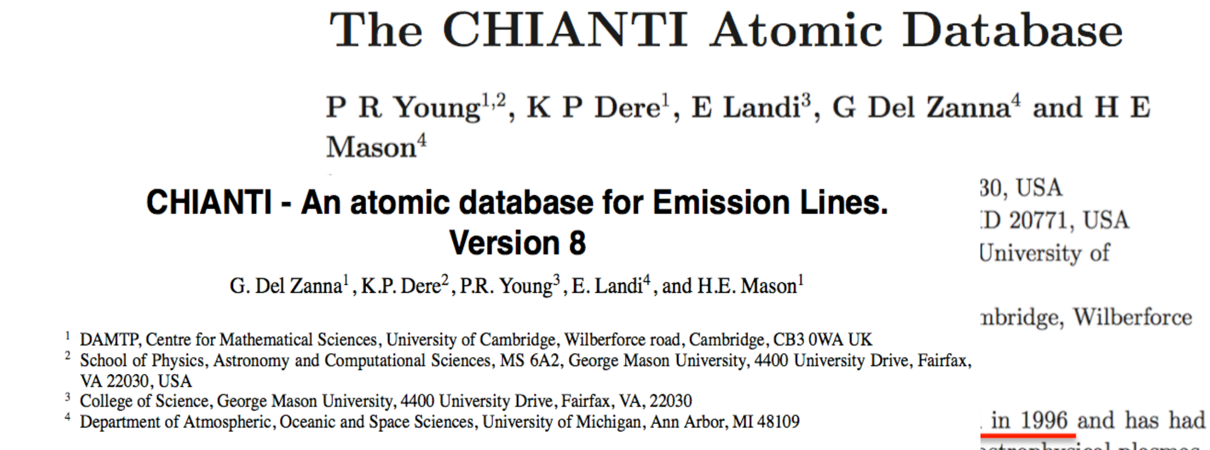


Fig. 4. Maximum magnetic intensification W_{max}/W_0 as a function of the number of Zeeman components of the fictitious iron line at λ 4500



The CHIANTI Atomic Database

P R Young[1,2], K P Dere[1], E Landi[3], G Del Zanna[4] and H E Mason[4]

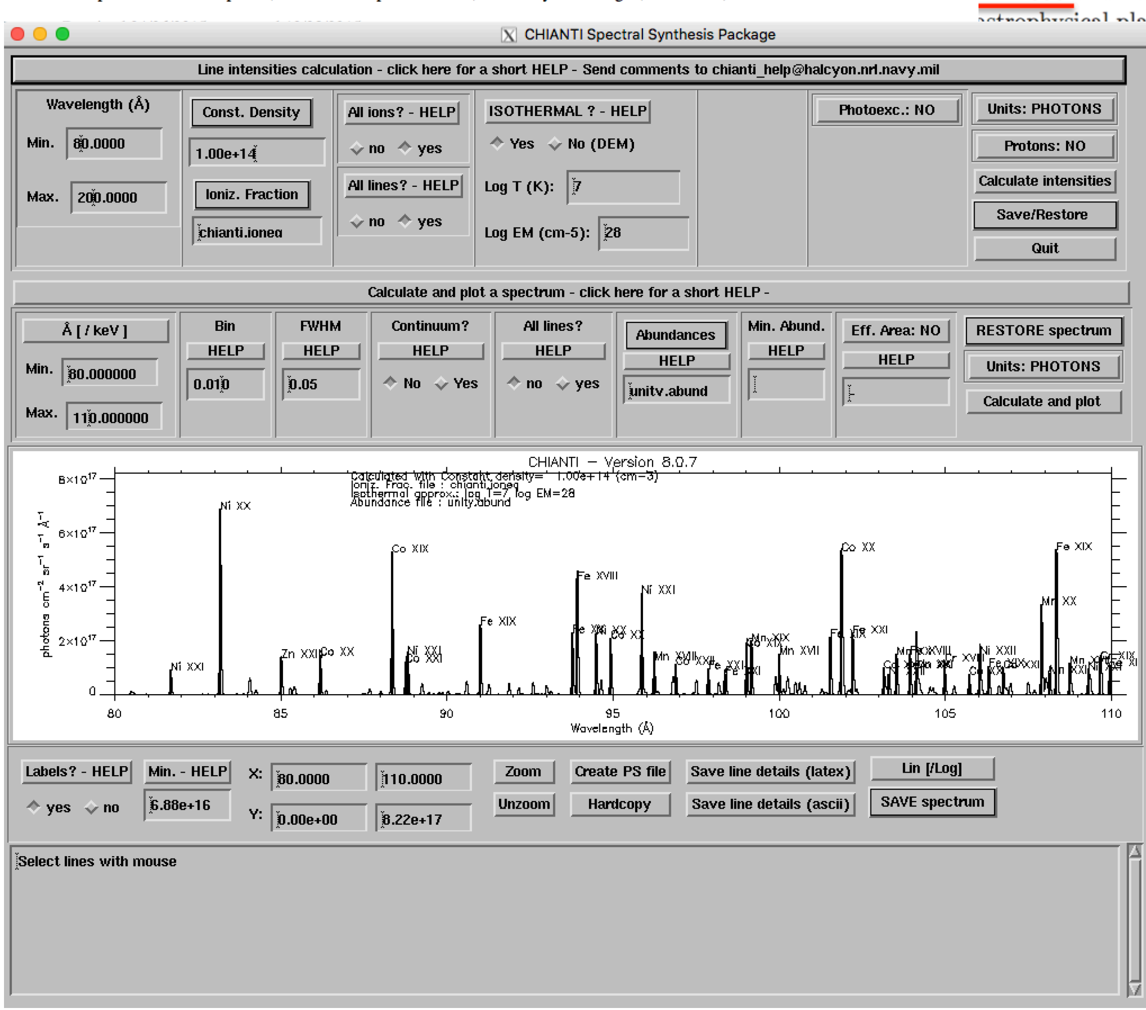
30, USA
D 20771, USA
University of
nbridge, Wilberforce

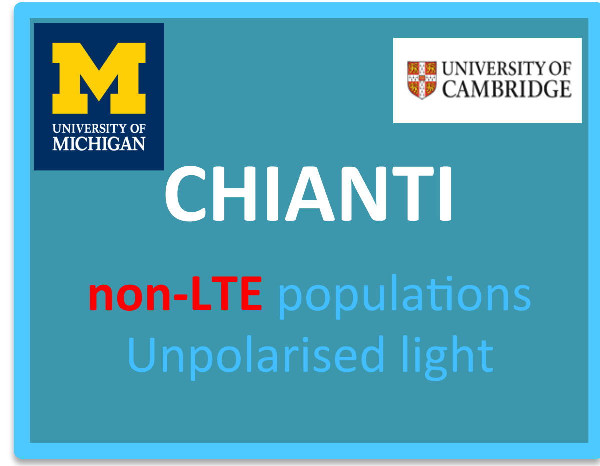
in 1996 and has had
astrophysical plasmas.
omic
NTI,
zinc.
ssed.
and

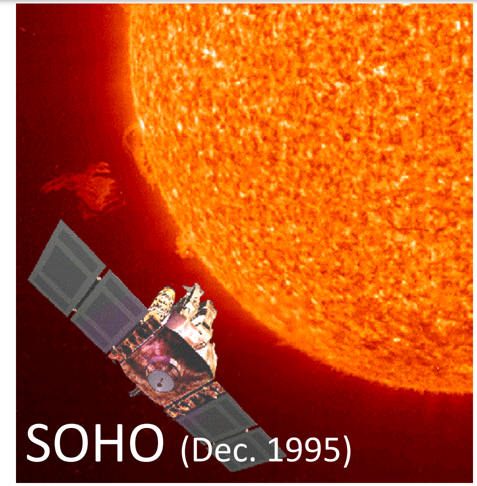
CHIANTI - An atomic database for Emission Lines. Version 8

G. Del Zanna[1], K.P. Dere[2], P.R. Young[3], E. Landi[4], and H.E. Mason[1]

[1] DAMTP, Centre for Mathematical Sciences, University of Cambridge, Wilberforce road, Cambridge, CB3 0WA UK
[2] School of Physics, Astronomy and Computational Sciences, MS 6A2, George Mason University, 4400 University Drive, Fairfax, VA 22030, USA
[3] College of Science, George Mason University, 4400 University Drive, Fairfax, VA, 22030
[4] Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, Ann Arbor, MI 48109







Ions in CHIANTI 8.0

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII	XXIX	XXX
H	25																													
He	49	25																												
C	42	204	20	331	49	25																								
N	47	58	204	20	268	49	25																							
O	7	35	46	204	166	268	49	25																						
Ne	-	138	86	22	49	204	46	243	49	36																				
Na	-	209	195	10	13	20	204	10	204	49	25																			
Mg	-	161	209	195	86	72	46	204	108	243	49	25																		
Al	-	20	161	209	195	10	15	20	204	10	243	49	25																	
Si	-	29	20	161	209	195	86	72	46	204	92	243	49	25																
P	-	-	-	-	161	209	3	10	15	20	204	10	204	45	25															
S	60	70	53	52	16	161	209	195	86	72	72	204	92	243	49	25														
Cl	-	5	5	5	-	-	-	-	-	10	15	20	204	10	204	49	25													
Ar	-	-	5	30	5	-	16	161	209	195	86	72	15	204	92	243	49	24												
K	-	-	-	-	5	5	-	-	161	209	3	10	15	20	204	10	204	49	25											
Ca	-	41	-	-	5	5	27	40	283	161	209	195	86	91	46	204	92	243	49	25										
Ti	-	-	-	-	-	-	-	-	-	-	16	161	209	3	10	72	20	15	10	20	-	-								
Cr	-	-	-	-	-	-	13	31	48	-	-	-	16	161	209	3	10	15	20	204	10	243	-	-						
Mn	-	-	-	-	-	-	-	13	31	48	-	-	-	-	161	209	3	10	15	20	204	10	204	-	-					
Fe	-	142	322	37	34	96	9	536	915	552	996	912	749	739	283	161	267	337	636	375	620	548	196	243	49	25				
Ni	-	17	-	-	-	-	-	-	-	-	599	31	48	143	483	40	159	161	209	195	58	15	20	204	92	243	49	25		
Zn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	161	209	-	10	72	20	-	10	243	49	-

≤ 10 levels
< 100 levels
≥ 100 levels

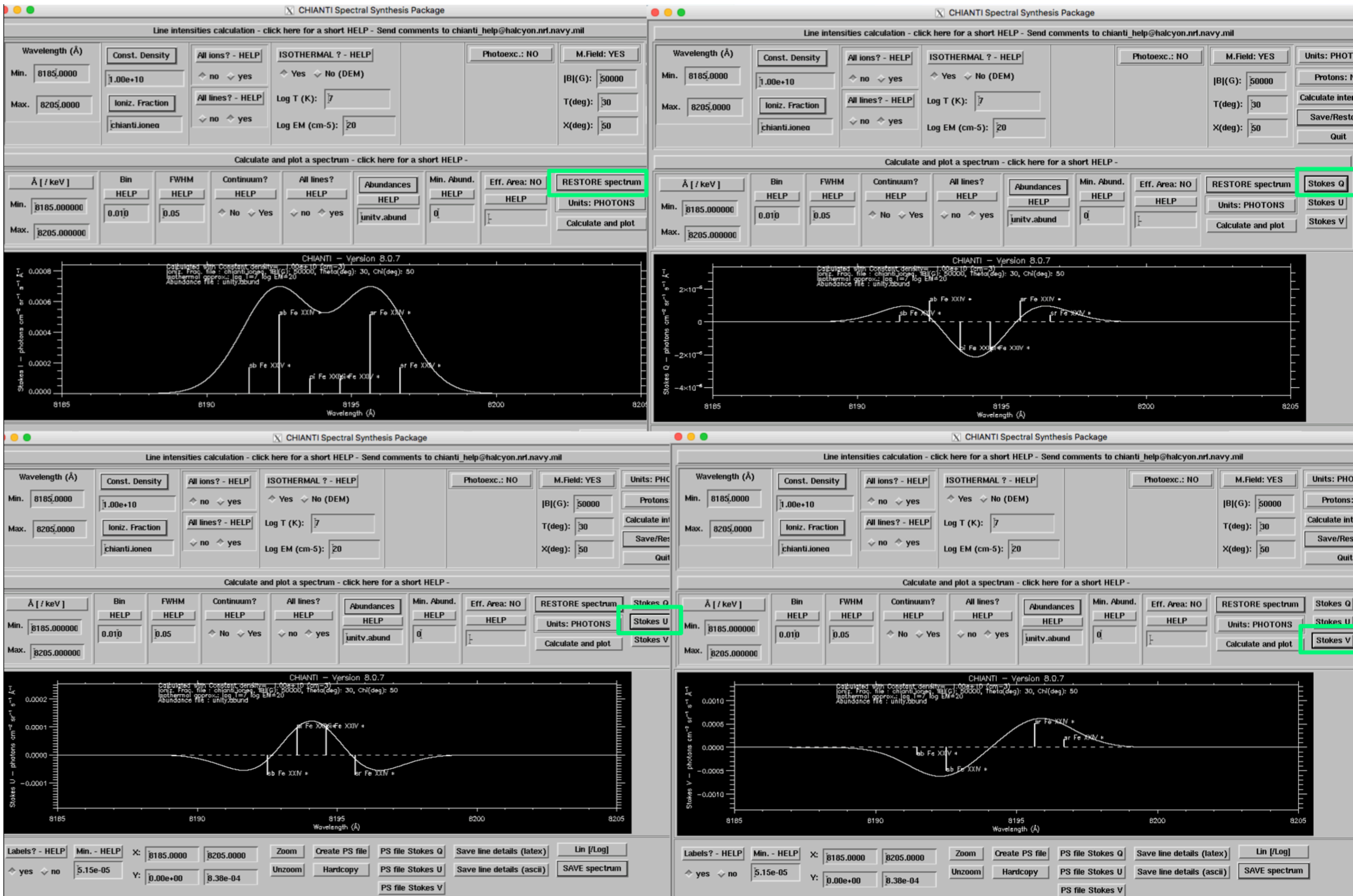
Introduction of Zeeman splitting in CHIANTI

Part of: Laboratory and Astrophysical Plasmas: New Perspectives

Published online by Cambridge University Press: **09 October 2020**

M. Giarrusso, E. Landi, G. Del Zanna and F. Leone

A new version in polarised light



CHIANTI has been applied to the Frascati Tokamak Unit Plasma Spectra

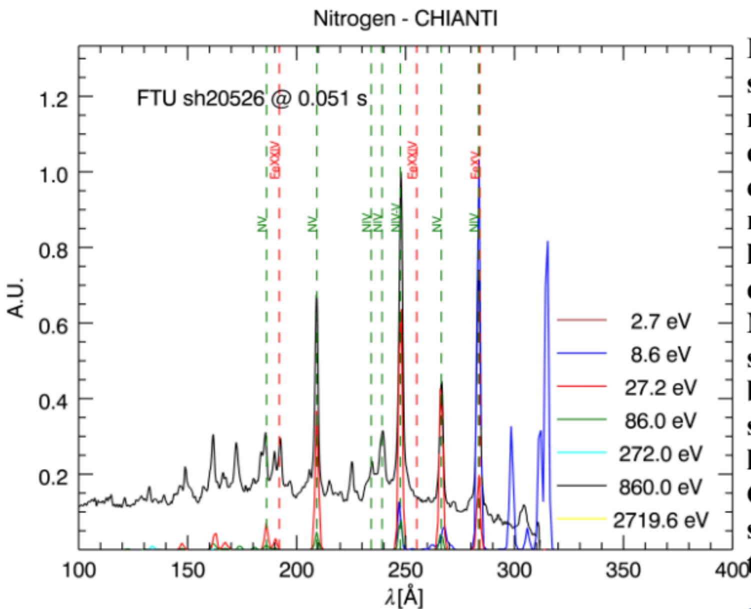


Fig. 4: VUV spectrum detected on FTU using the SPRED spectrometer in the early phase of a discharge dominated by nitrogen (black line). The vertical dashed lines are the experimentally identified lines of Fe (red) and N (green). The calculated spectra of N from the CHIANTI database are reported in different colors for each temperature as listed on the legend. The collisional-radiative model assumed a constant density of 10^{19} m^{-3}. It can be observed that the most prominent N lines are associated to a temperature of about 30 eV (red). The strong blue line at 28.35 nm, on the other hand, is not matched by any other N line that should appear on its long wavelength side, thus prompting the notion that this line may be the FeXV line instead. Other experimental N lines do not appear from the CHIANTI calculation [illegible]ith the expected intensity, which is not surprising give[illegible]ly ionizing conditions of the plasma at that time

[illegible] Giarrusso

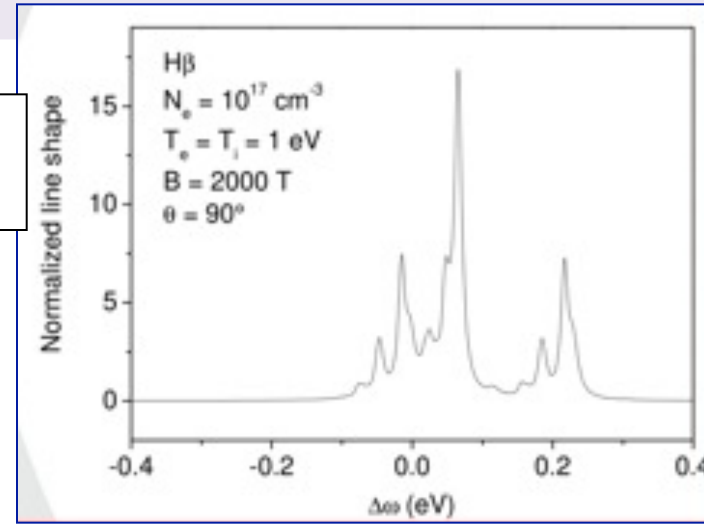
We were conscripted for the DTT Passive Diagnostics
Plasma is not for free

DTT	Proposal for Services DTT 2022-DIA-DIC/DOC Diagnostics Project: Spectroscopy	DTT ID: DIA-TEN-68525	Page: **11/12**
		External ID: **N.A.**	Rev. 1.0

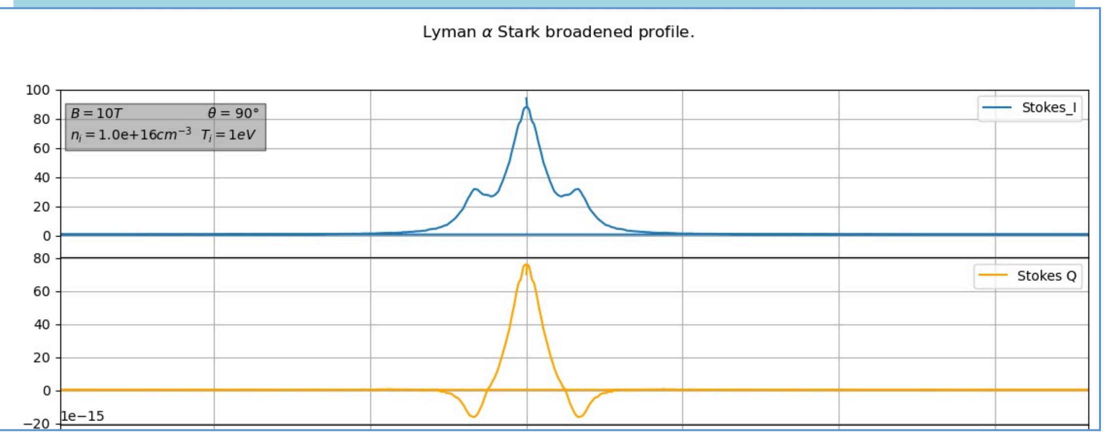
Francesco	Leone	francesco.leone@inaf.it	INAF**	CXRS/MES	1	0
Marina	Giarrusso	marina.giarrusso	INAF**	VUV, spectra simulations	2	0

Hydrogen lines in highly magnetised plasmas

no selection rules,
unpredictable profiles



At the Marseille University, a PhD student (Lorenzo Giustolisi) is working on Zeeman-Stark profiles of Hydrogen lines in polarised light to be included in full-stokes NLTE-ZCHIANTI



Hydrogen full-stokes profiles for White-Dwarf diagnostics

New techniques for magnetic field measurements
No matter how weak

First direct measurement of the Magnetic Field Transverse Component from derivatives of the Stokes line profiles

$$\frac{V_\lambda}{I_\lambda} = -4.67\times10^{-13}\bar{g}\lambda^2 B_\parallel \frac{1}{I_\lambda}\frac{\partial I_\lambda}{\partial\lambda}$$
$$\frac{Q_\lambda}{I_\lambda} = -5.45\times10^{-26}\bar{G}\lambda^4 B_\perp^2 \cos 2\chi \frac{1}{I_\lambda}\frac{\partial^2 I_\lambda}{\partial\lambda^2}$$
$$\frac{U_\lambda}{I_\lambda} = -5.45\times10^{-26}\bar{G}\lambda^4 B_\perp^2 \sin 2\chi \frac{1}{I_\lambda}\frac{\partial^2 I_\lambda}{\partial\lambda^2}$$

The Astrophysical Journal, 848:107 (8pp), 2017 October 20 https://doi.org/10.3847/1538-4357/aa8d72

CrossMark

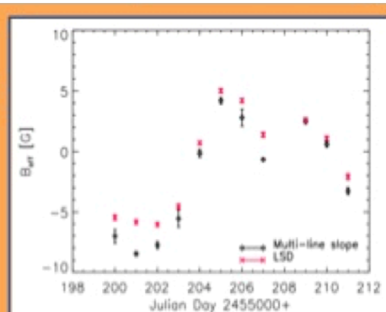
A Method to Measure the Transverse Magnetic Field and Orient the Rotational Axis of Stars

Francesco Leone[1], Cesare Scalia[1], Manuele Gangi[1], Marina Giarrusso[1], Matteo Munari[2], Salvatore Scuderi[2], Corrado Trigilio[2], and Martin J. Stift[3]
[1] Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, I-95123 Catania, Italy
[2] INAF—Osservatorio Astrofisico di Catania, Via S. Sofia 78, I-95123 Catania, Italy
[3] Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland
Received 2016 June 9; revised 2017 September 14; accepted 2017 September 14; published 2017 October 20

The Ultimate Measurement of Magnetic Fields

in 5 years from literature

100 Gauss → → → → 1 Gauss → → → → Sub-Gauss (33 mmGauss of 89 Her)



Monthly Notices of the Royal Astronomical Society
MNRAS 472, 3554–3563 (2017) doi:10.1093/mnras/stx2090

The multi-line slope method for measuring the effective magnetic field of cool stars: an application to the solar-like cycle of ϵ Eri

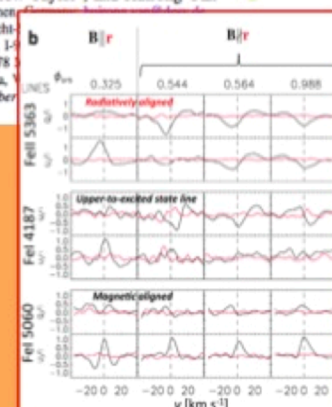
C. Scalia,[1,2★] F. Leone,[1,2★] M. Gangi,[1,2★] M. Giarrusso[1,2] and M. J. Stift[3]
[1] Università di Catania, Dipartimento di Fisica e Astronomia, Sezione Astrofisica, Via S. Sofia 78, I-95123 Catania, Italy
[2] INAF – Osservatorio Astrofisico di Catania, Via S. Sofia 78, I-95123 Catania, Italy
[3] Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland, UK

The Astrophysical Journal Letters, 902:L7 (7pp), 2020 October 10 https://doi.org/10.3847/2041-8213/abb8e1

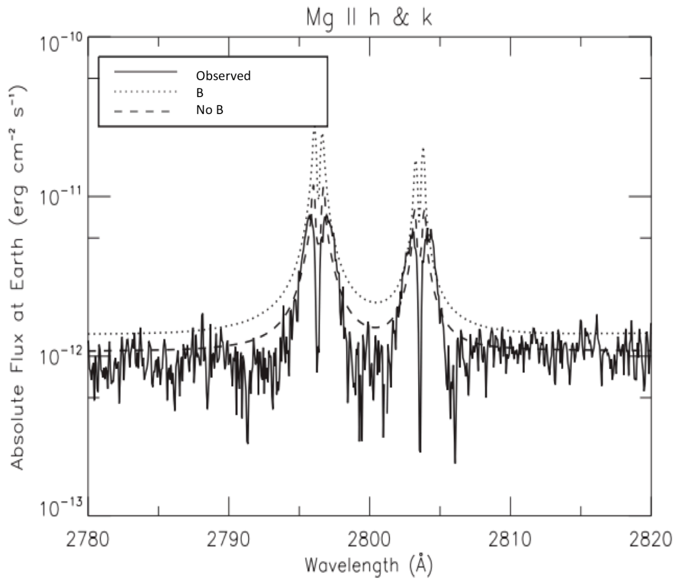
CrossMark

Discovery of Ground-state Absorption Line Polarization and Sub-Gauss Magnetic Field in the Post-AGB Binary System 89 Her

Heshou Zhang[1,2], Manuele Gangi[3,4], Francesco Leone[5], Andrew Taylor[1], and Huirong Yan[1,2,6]
[1] Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, D-15738 Zeuthen
[2] Institut für Physik und Astronomie, Universität Potsdam, Haus 28, Karl-Liebknecht-
[3] INAF - Osservatorio Astrofisico di Catania, Via S. Sofia 78, I-9
[4] INAF - Osservatorio Astronomico di Roma, Via Frascati 33, I-00078
[5] Università di Catania, Dipartimento di Fisica e Astronomia, S
Received 2020 February 4; revised 2020 July 20; accepted 2020 September



NLTE Radiative Transfer In Magnetic Plasmas (NERTIMP)

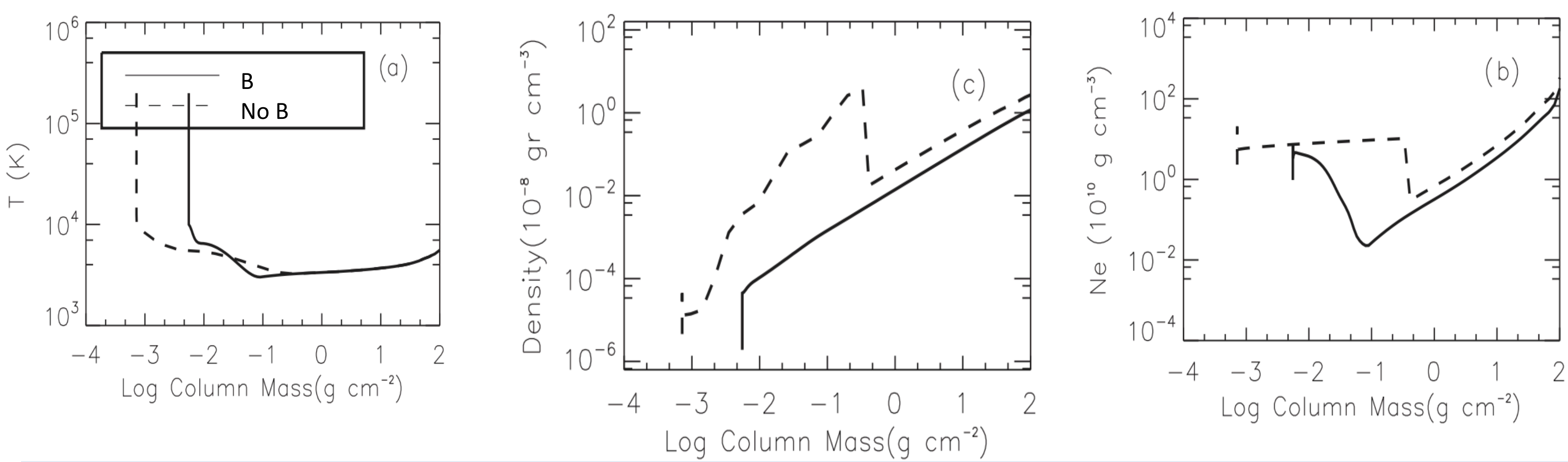


I. Busá et al. 2017

NLTE spectral synthesis in magnetised plasma

Innocenza Busà OACT	0.6 FTE + 0.3 P
Giovanni Catanzaro OACT	0.6 FTE
Francesco Leone UNICT	0.0 FTE

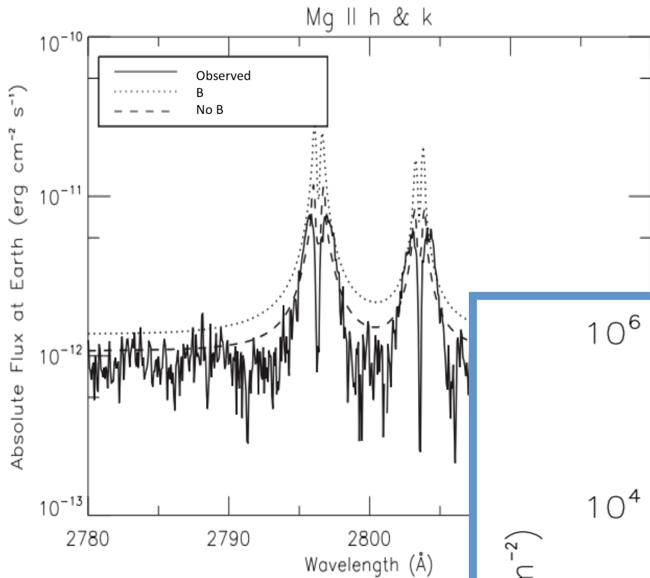
FTE nel triennio 2022-2024



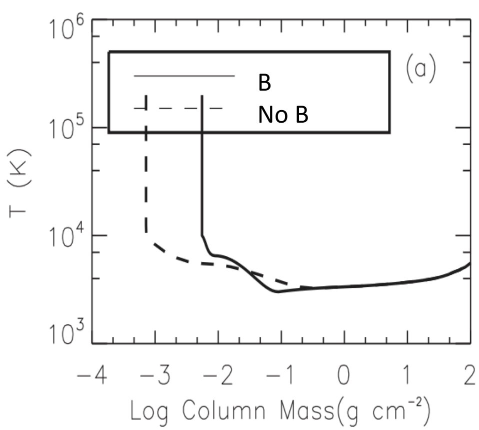
HR 7428 atmosphere with and without magnetic field pressure.

Errors in electron density and gas pressure are up to orders of magnitude

NLTE Radiative Transfer In Magnetic Plasmas (NERTIMP)

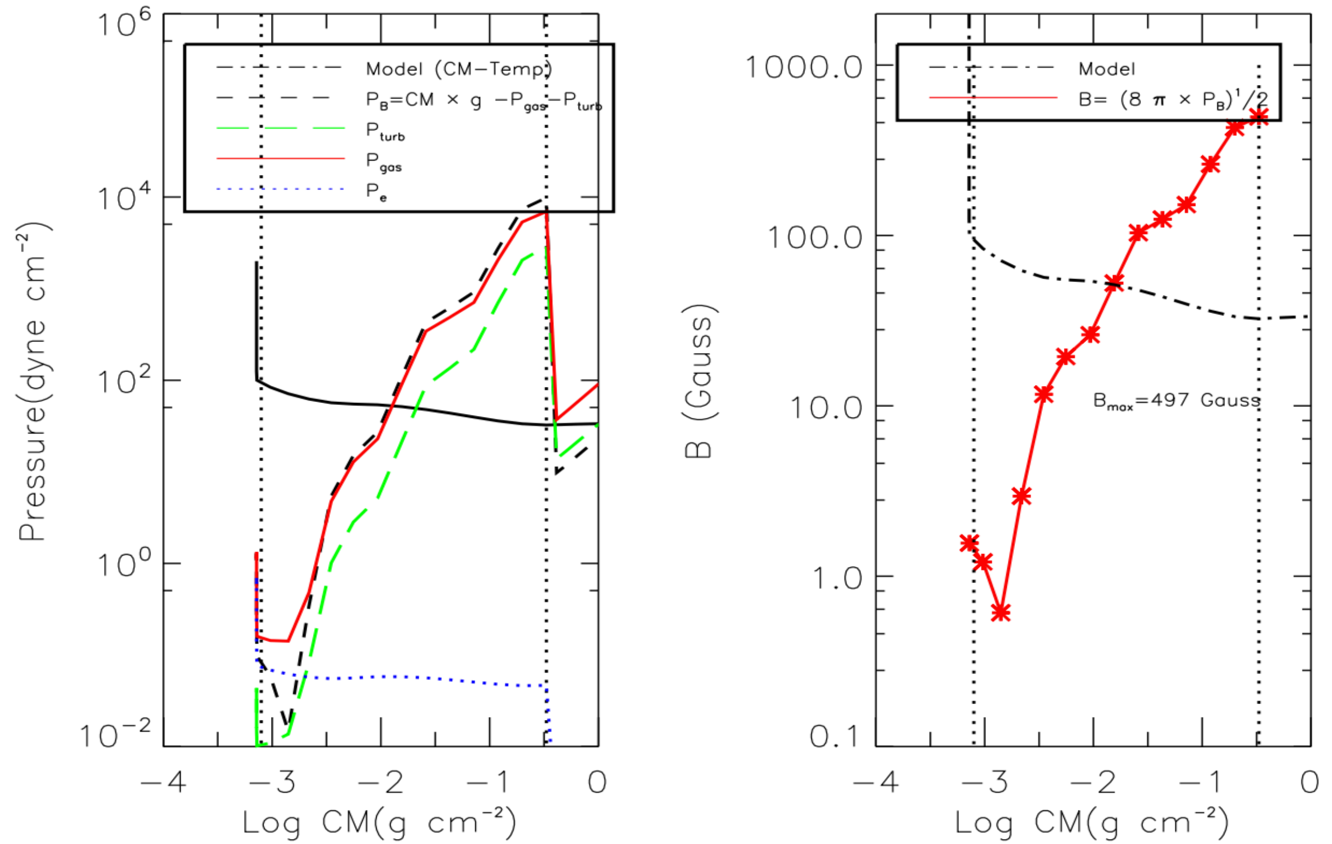


I. Busá et al. 2017



NLTE spectral synthesis in magnetised plasma

Innocenza Busà OACT 0.6 FTE + 0.3 P

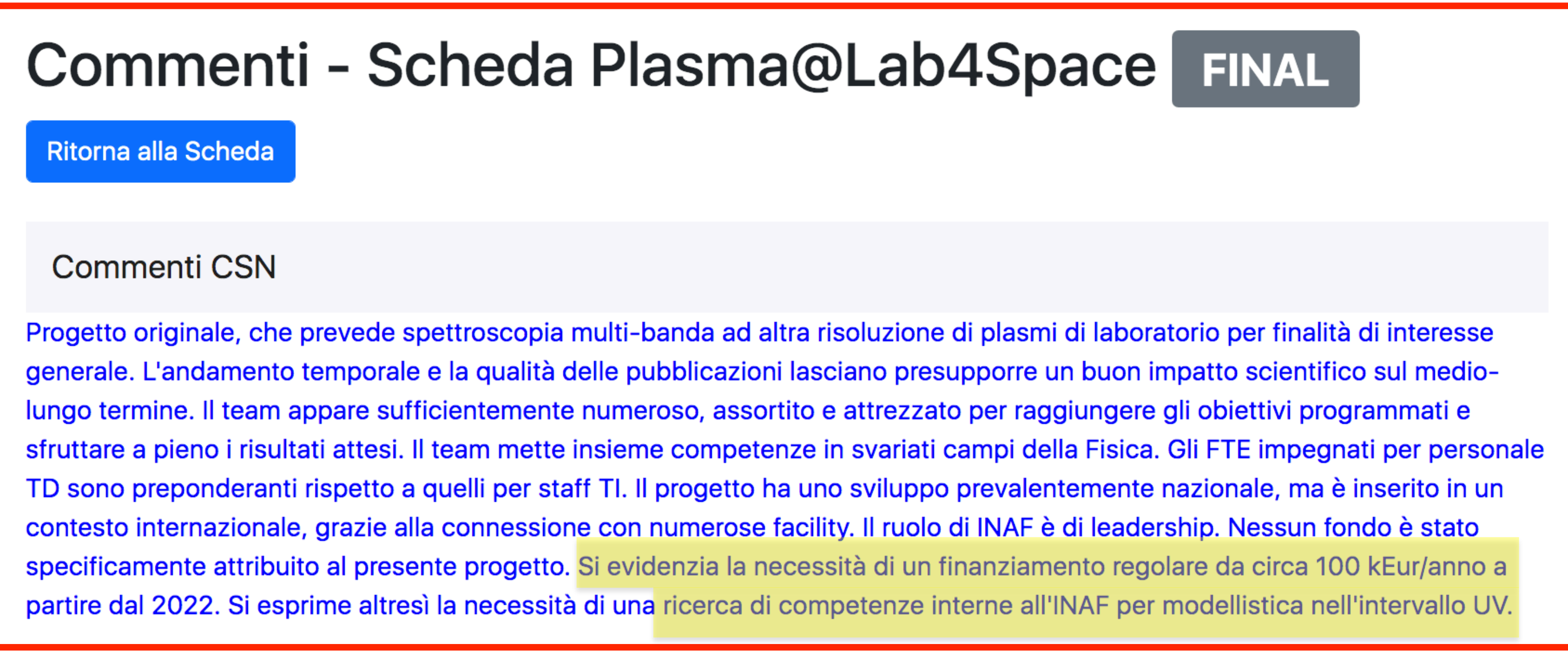


HR 7428 atmosphere with and without magnetic field pressure.

Errors in electron density and gas pressure are up to orders of magnitude

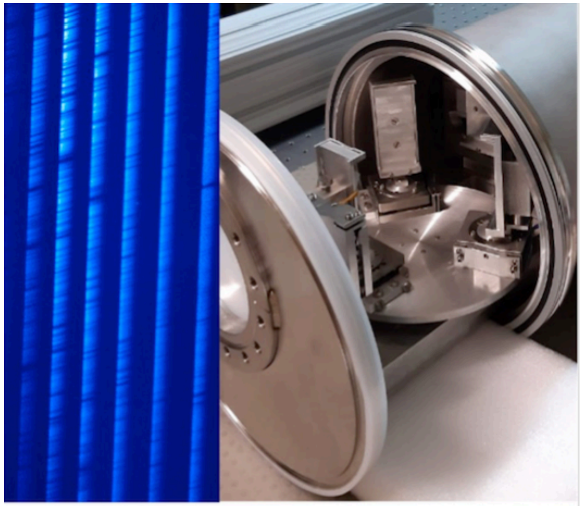
Funding, Strengths and Critical points

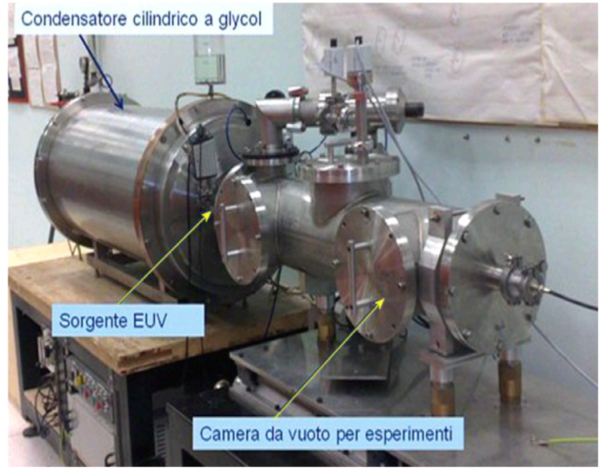
- Plasma Laboratories are supported from respective institutions
- Funds are necessary to couple instruments, recruiting and transfers



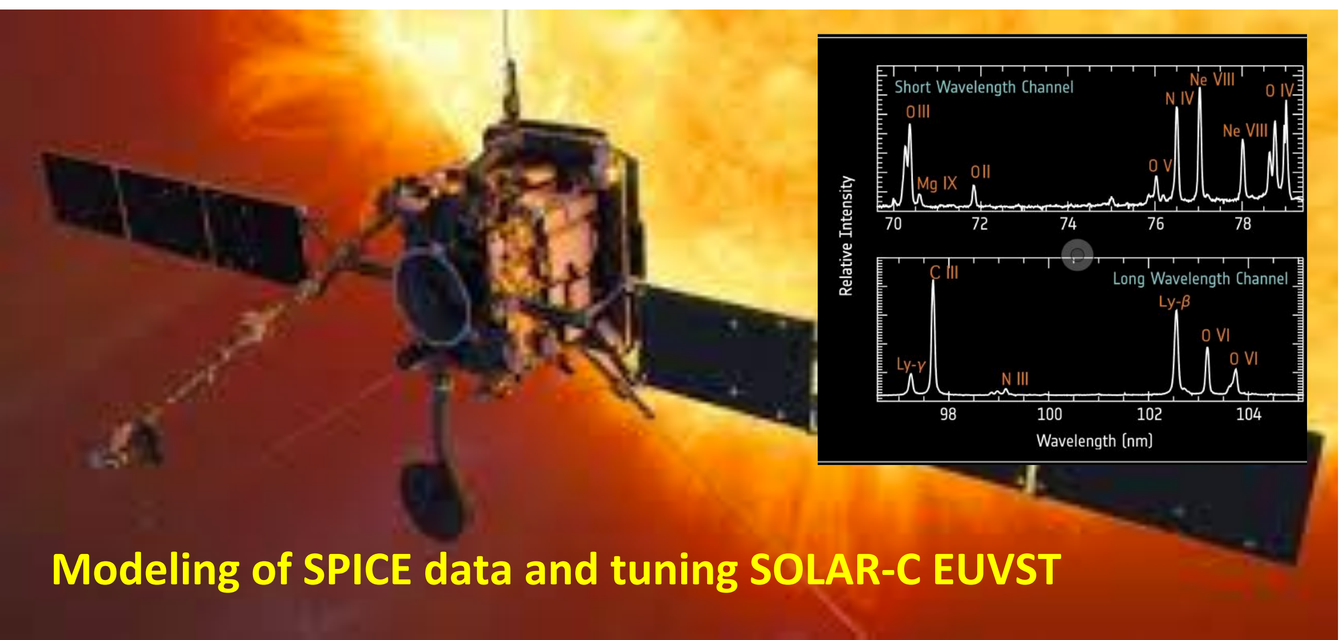
Large Grant (PI F. Leone)

LAPSUS (+ VIS Spectroscopy) + **Discharge Plasma Producer** = **An atomic database for FUV transitions**





Request: 200 k€ for optomechanical interface + 1 UV expert



Solar Physicists:
Vincenzo Andretta
Giulio Del zanna
Enrico Landi
Marco Romoli
Daniele Spadaro

Mini Grant: Near-infrared spectroscopy of REEs with GIANO-B (PI G. Catanzaro)

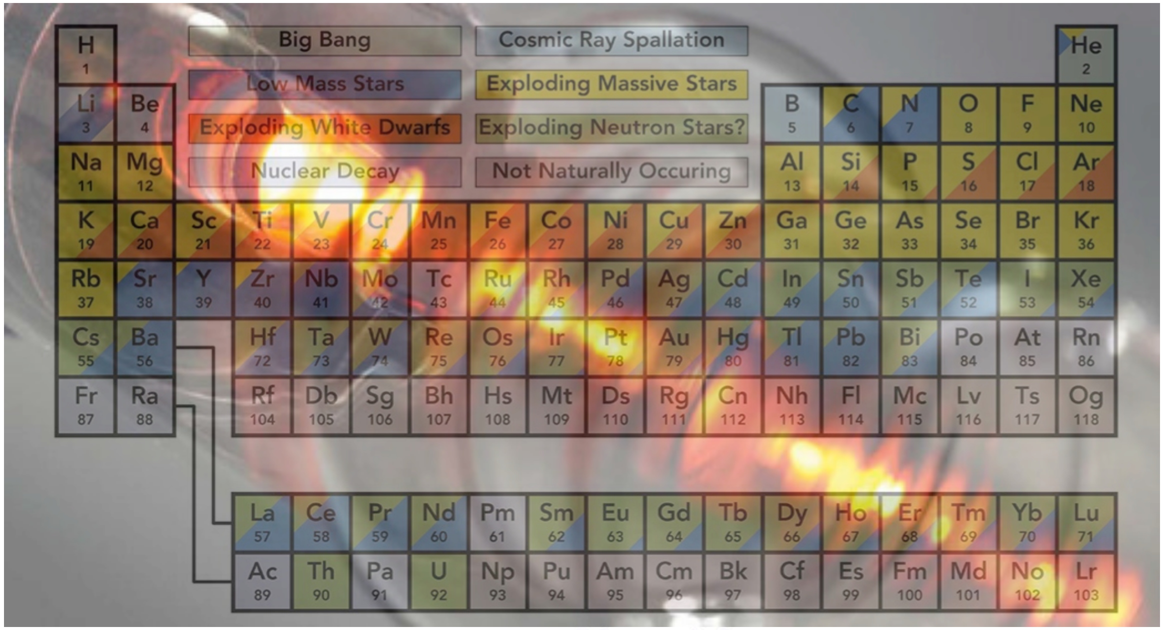


Figure 1. Cosmic origin of chemical elements

Element (Z)	N_{lines} (1000 ÷ 9000 Å) NIST	VALD	Kurucz	N_{lines} (9000 ÷ 25000 Å) NIST	VALD	Kurucz
La (57)	731	665	2188	9	4	0
Ce (58)	1000	19238	2566	23	680	0
Pr (59)	1206	1472	577	19	291	0
Nd (60)	735	1618	1284	0	3	0
Pm (61)	424	0	0	0	0	0
Sm (62)	797	1872	1581	0	31	0
Eu (63)	797	1672	1273	0	17	10
Gd (64)	1031	1616	1399	5	18	1
Tb (65)	720	307	107	0	7	0
Dy (66)	651	2828	1183	0	240	0
Ho (67)	566	1406	90	0	6	0
Er (68)	637	2367	906	0	81	0
Tm (69)	981	9737	754	0	193	0
Yb (70)	777	5642	392	2	1173	0
Lu (71)	393	255	152	0	9	3

Table 1: Number of spectral lines present in VALD (Vienna Atomic Line Database; http://vald.astro.uu.se/) and Kurucz's databases for Rare-Earths (all ions included) in the UV+Vis and NIR range. NIST digits refer to experimental validated spectral lines.

20 k€ to extend the HRes-spectroscopy from VIS-CAOS@SLN to the NIR-GIANO@TNG

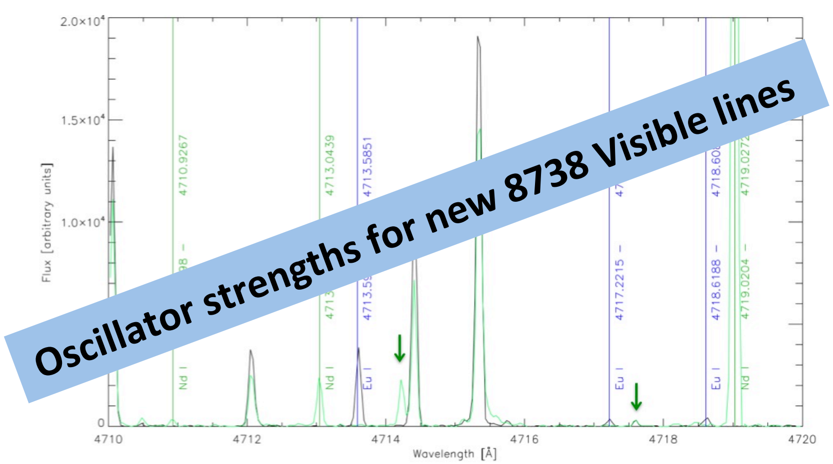


Figure 4. CAOS spectra of Eu-Ne (black) and Nd-Ne (green) Hollow-Cathode Lamps. NIST lines are marked with experimental and RItz wavelengths. In this small 10 Å chunk 2 unknown Nd lines are clearly visible.

Mini Grant: Near-infrared spectroscopy of REEs with GIANO-B (PI G. Catanzaro)

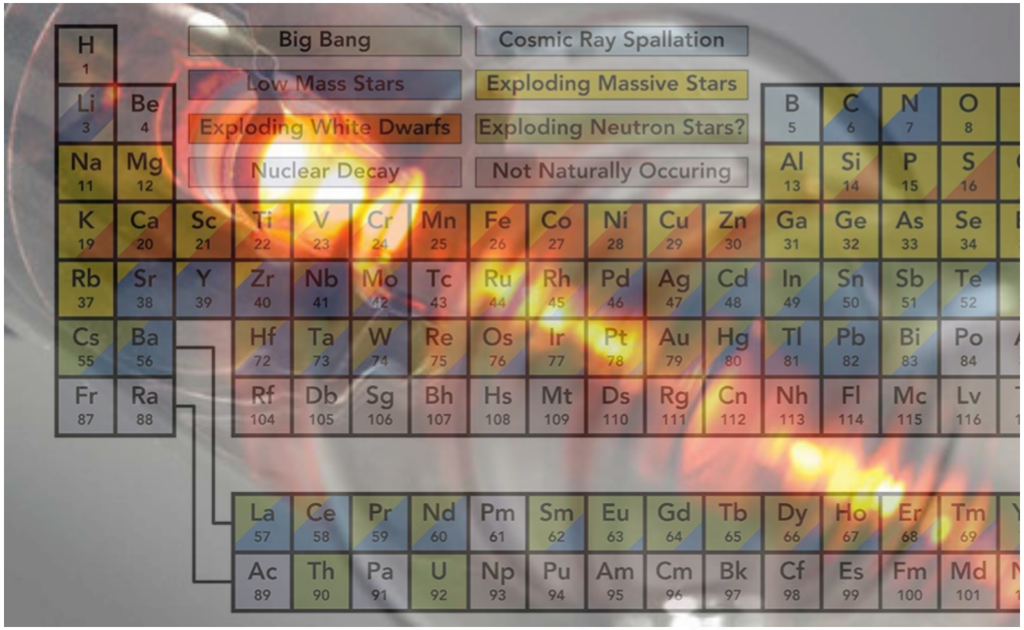


Figure 1. Cosmic origin of chemical elements

20 k€ to extend the HRes-spectroscopy from VIS-(

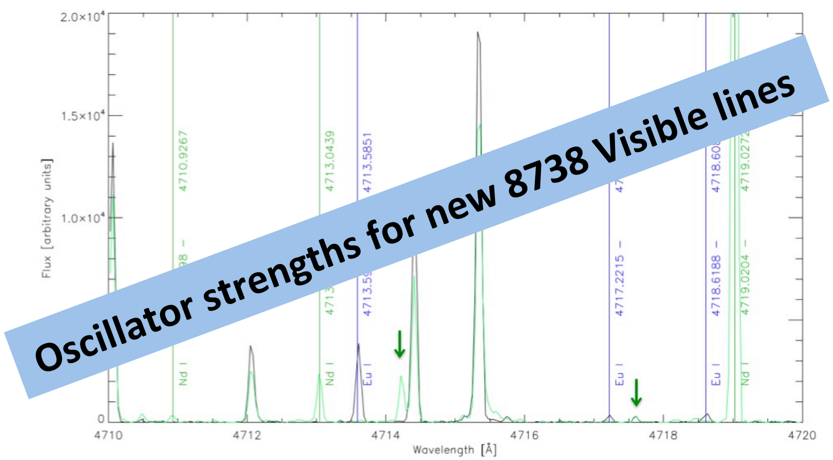
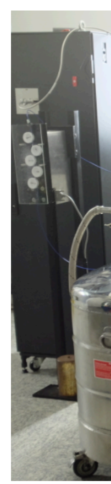


Figure 4. CAOS spectra of Eu-Ne (black) and Nd-Ne (green) Hollow-Cathode Lamps. NIST lines are marked with experimental and RItz wavelengths. In this small 10 Å chunk 2 unknown Nd lines are clearly visible.



TNG 1996-2021

telescopio nazionale galileo

Fundación Galileo Galilei INAF, Fundación Canaria - Telescopio Nazionale Galileo

Breña Baja, March 24th, 2022

TO WHOM MAY CONCERN

This letter endorses the content of the project *Near-infrared spectroscopy of rare-earths hollow cathode lamps with GIANO-B* led by Dr. Giovanni Catanzaro (INAF-OA Catania), to be submitted to the INAF *Bando per il finanziamento della Ricerca Fondamentale 2022*.

Telescopio Nazionale Galileo hosts the near-infrared spectrograph GIANO-B, currently equipped with an U-Ne lamp. GIANO-B is used for observational studies at the frontiers of research fields like exoplanetary science and chemical compositions of the different stellar populations.

The project is aimed at measuring the wavelengths and intensities of Rare-Earth-Element lines in the near infrared with great accuracy. We are ready to take GIANO-B spectra to test the lamps selected by the proponents in order to improve the existing atomic databases. Moreover, we are keen to substitute the current U-Ne lamp with one of these new devices as wavelength calibrator of the GIANO-B spectrograph, due to its age and to other small instrumental problems we met.

Therefore, TNG has a strong interest in the full characterization of the proposed lamps for their astronomical use .

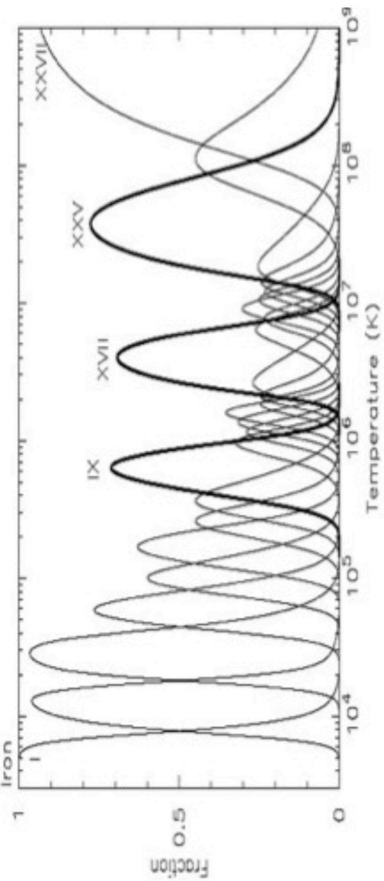
Sincerely yours, Ennio Poretti

Dr. Ennio Poretti
Director of the Telescopio Nazionale Galileo
Fundaciòn Galileo Galilei-INAF

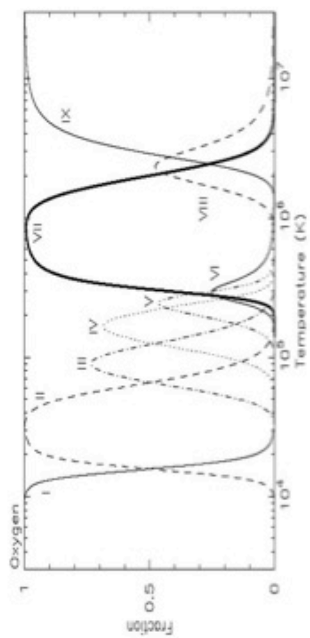
Fundación Galileo Galilei – INAF, Fundación Canaria
Dirección
C.I.F.: G-38783312 Rambla José Ana Fernández Pérez, 7 - 38712 Breña Baja, TF - Spain
Tel.: +34 922 433666 Fax: +34 922 42 05 08

PnRR - Strengthening the Italian Leadership in ELT and SKA

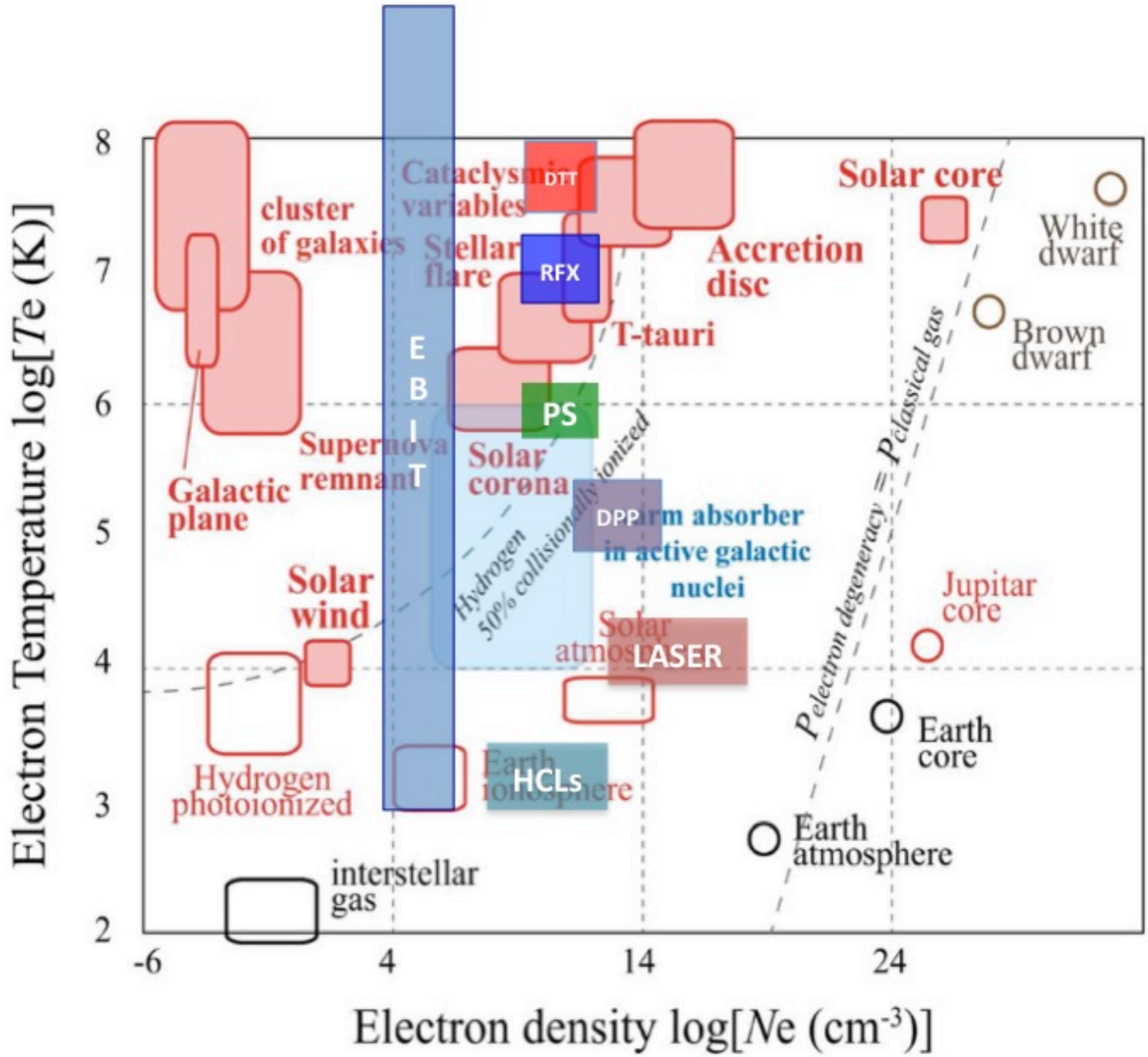
Iron



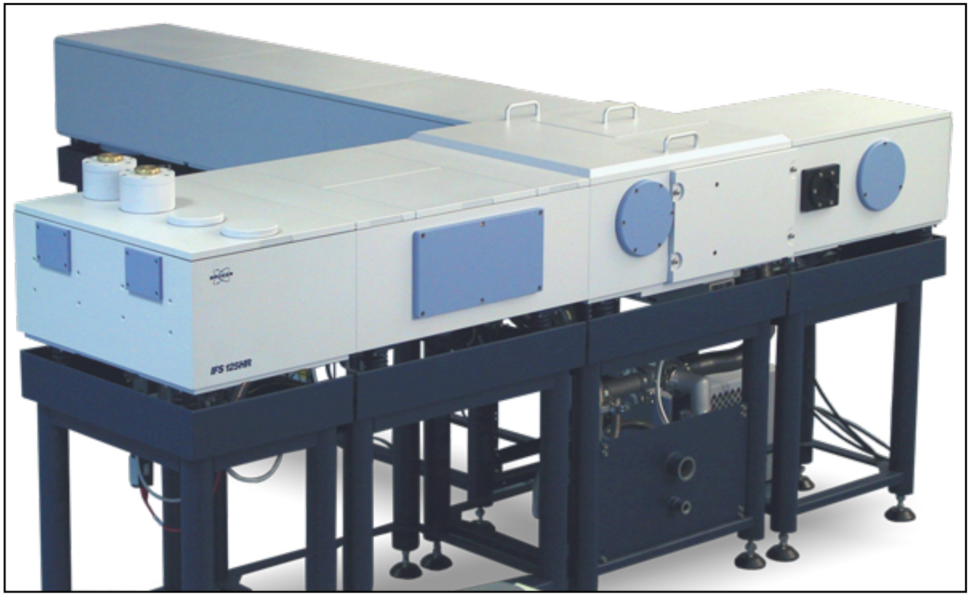
Oxygen



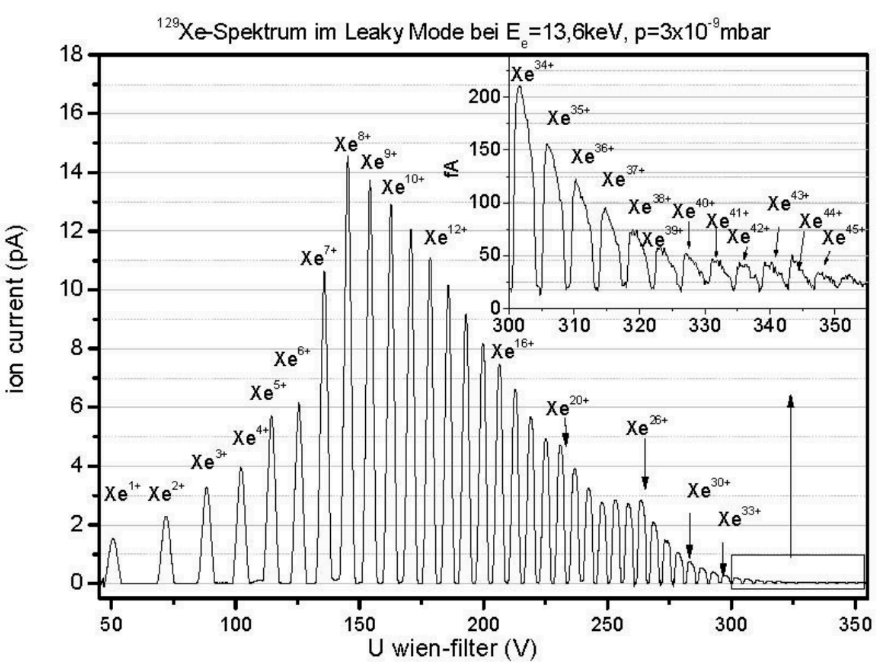
Electron Beam Ion Trap



PnRR - Strengthening the Italian Leadership in ELT and SKA



High Resolution (R > 100,000) Fourier Spectrograph in the 0.2-2.5 μm range



Electron Beam Ion Trap

Plasma@Lab4Space

can be more than

a program of

laboratory-plasma spectropolarimetry

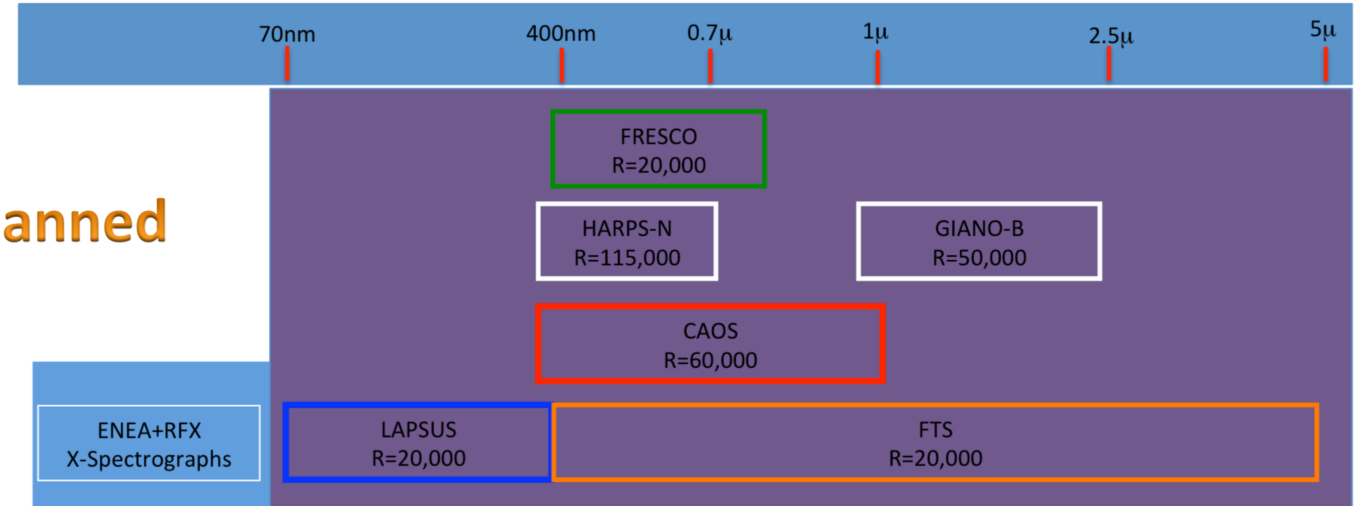
to build an

experimental atomic database

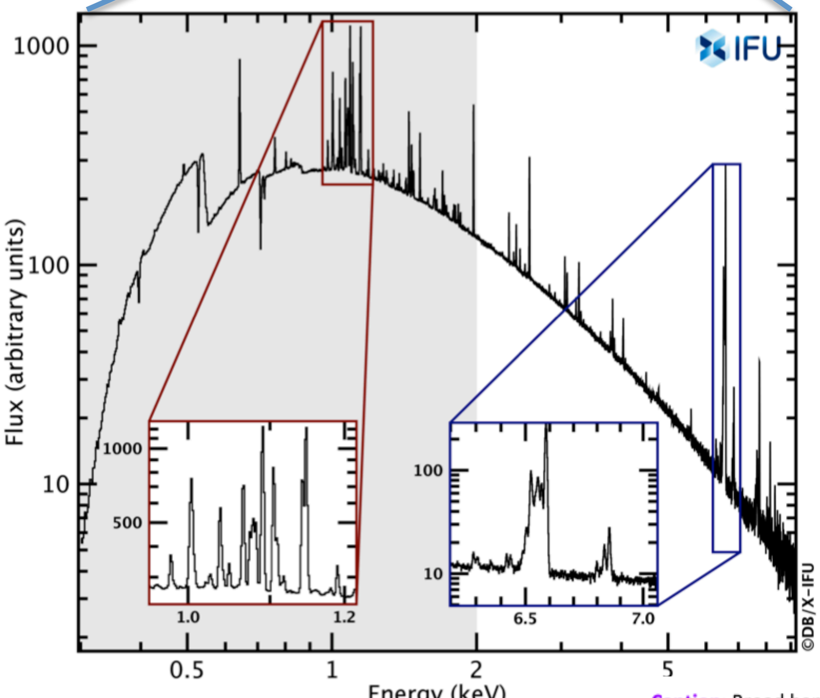
for spectral lines

of highly-ionised atoms

from Vacuum-UV to NIR

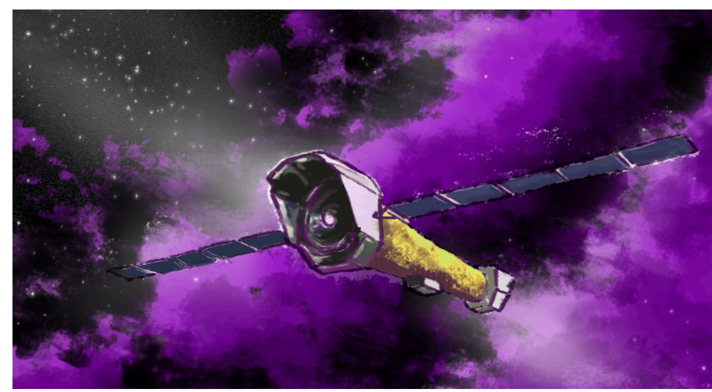


We also planned



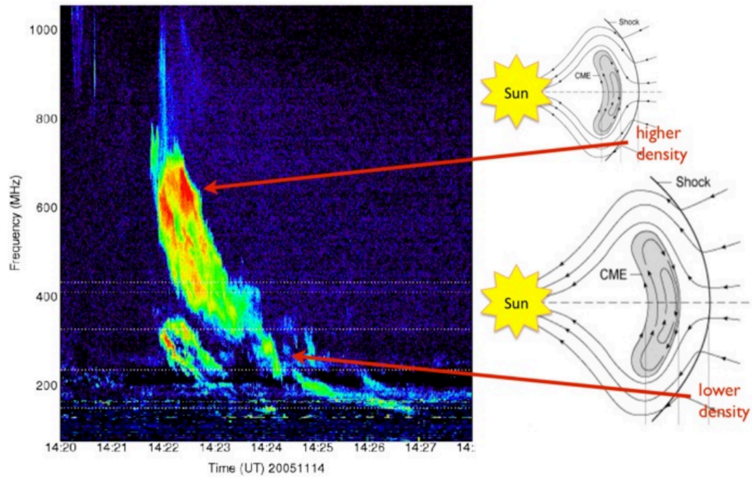
An Atomic Database for ATHENA

Advanced Telescope for High Energy Astrophysics



Caption: Broad band simulated Athena X-IFU spectrum of Perseus as derived from the early Hitomi/SXS observation. A zoom on the Iron L and K line complex highlights the wealth of the X-IFU spectrum. The grey area displaying a large number of lines was not observed by Hitomi/SXS. This energy range will be observed by XRISM/Resolve.

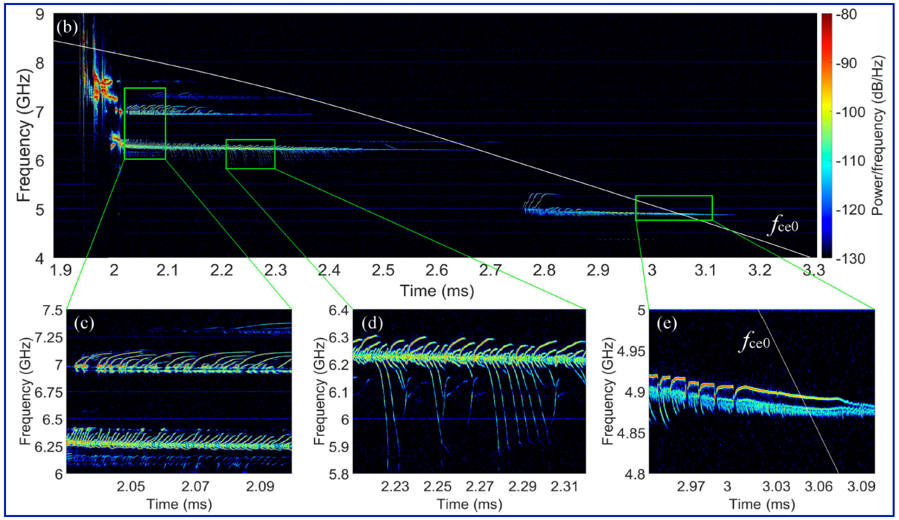
Plasma instabilities and Radio Emission in laboratory



Observation of quasi-periodic frequency sweeping in electron cyclotron emission of nonequilibrium mirror-confined plasma

M. E. Viktorov[a], A. G. Shalashov, D. A. Mansfeld and S. V. Golubev

Institute of Applied Physics of Russian Academy of Sciences – 46 Ulyanov Str., 603950, Nizhny Novgorod, Russia



Microphysics of Cosmic Plasmas pp 619-637 | Cite as

Laboratory astrophysics: Investigation of planetary and astrophysical maser emission

Authors | Authors and affiliations

R. Bingham, D. C. Speirs, B. J. Kellett, I. Vorgul, S. L. McConville, R. A. Cairns, A. W. Cross, A. D. R. Phelps, K. Ronald

Part of the Space Sciences Series of ISSI book series (SSSI, volume 47)

Abstract

This paper describes a model for cyclotron maser emission applicable to planetary auroral radio emission, the stars UV Ceti and CU Virginus, blazar jets and astrophysical shocks. These emissions may be attributed to energetic electrons moving into convergent magnetic fields that are typically found in association with dipole like planetary magnetospheres or shocks. It is found that magnetic compression leads to the formation of a velocity distribution having a horseshoe shape as a result of conservation of the electron magnetic moment. Under certain plasma conditions where the local electron plasma frequency ω_{pe} is much less than the cyclotron frequency ω_{ce} the distribution is found to be unstable to maser type radiation emission. We have established a laboratory-based facility that has verified many of the details of our original theoretical description and agrees well with numerical simulations. The experiment has demonstrated that the horseshoe distribution produces cyclotron emission at a frequency just below the local electron cyclotron frequency, with polarisation close to X-mode and propagating nearly perpendicularly to the electron beam motion. We discuss recent developments in the theory and simulation of the instability including addressing radiation escape problems, and relate these to the laboratory, space, and astrophysical observations. The experiments showed strong narrow band EM emissions at frequencies just below the cold-plasma cyclotron frequency as predicted by the theory. Measurements of the conversion efficiency, mode and spectral content were in close agreement with the predictions of numerical simulations undertaken using a particle-in-cell code and also with satellite observations confirming the horseshoe maser as an important emission mechanism in geophysical/astrophysical plasmas. In each case we address how the radiation can escape the plasma without suffering strong absorption at the second harmonic layer.

Plasmas are not only for spectroscopy or atomic physics

IOP Publishing Plasma Physics and Controlled Fusion
Plasma Phys. Control. Fusion **63** (2021) 095007 (10pp) https://doi.org/10.1088/1361-6587/ac138c

Fast dynamics of radiofrequency emission in FTU plasmas with runaway electrons

P Buratti[1,*], W Bin[2], A Cardinali[1], D Carnevale[3], C Castaldo[1], O D'Arcangelo[1], F Napoli[1], G L Ravera[1], A Selce[1], L Panaccione[1], A Romano[1] and FTU Team[4]

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Laboratory-RadioAstronomy

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P Leto ✉, C Trigilio, J Krtička, L Fossati, R Ignace, M E Shultz, C S Buemi, L Cerrigone, G Umana, A Ingallinera, C Bordiu, I Pillitteri, F Bufano, L M Oskinova, C Agliozzo, F Cavallaro, S Riggi, S Loru, H Todt, M Giarrusso, N M Phillips, J Robrade, F Leone

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We selected TRISTAN-MP
TRIdimensional STANford - Massive Parallel code

TRISTAN-MP is a fully relativistic Particle-In-Cell (PIC) code for plasma physics computations and self-consistently solves the full set of Maxwell's equations, along with the relativistic equations of motion for the charged particles. Fields are discretized on a finite 3D or 2D mesh, the computational grid; the code then uses time-centered and space-centered finite difference schemes to advance the equations in time via the Lorentz force equation, and to calculate spatial derivatives, so that the algorithm is second order accurate in space and time. The charges and currents derived from the particles' velocities and positions are then used as source terms to re-calculate the electromagnetic fields.

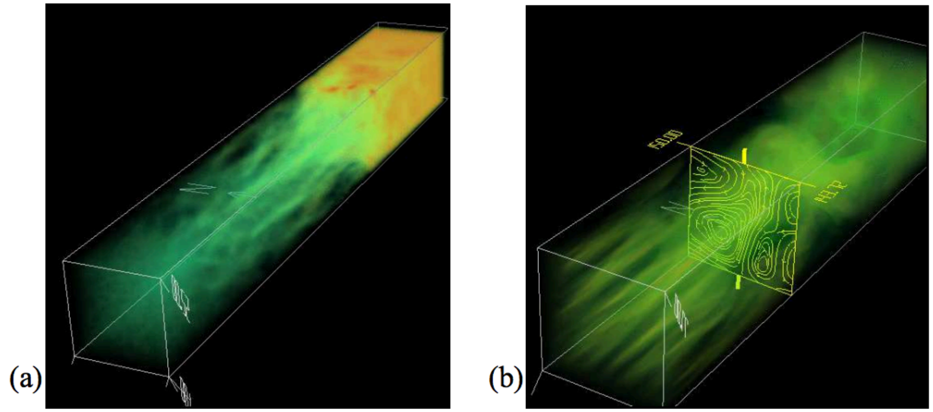


FIGURE 1. a) Filamentary structure of density in an unmagnetized shock. b) Generation of magnetic field around current filaments in the shock.

And even more if you participate

Conclusions

- No substantial budget, only a guaranteed and continuous support
- Do not waste efforts in training
- Present Team cannot exploit all possibilities, there is much more than planed.
  We are open to new ideas/suggestions

Thank you

Plasma@Lab4Space

a program of

laboratory-plasma spectropolarimetry

to build an

experimental atomic database

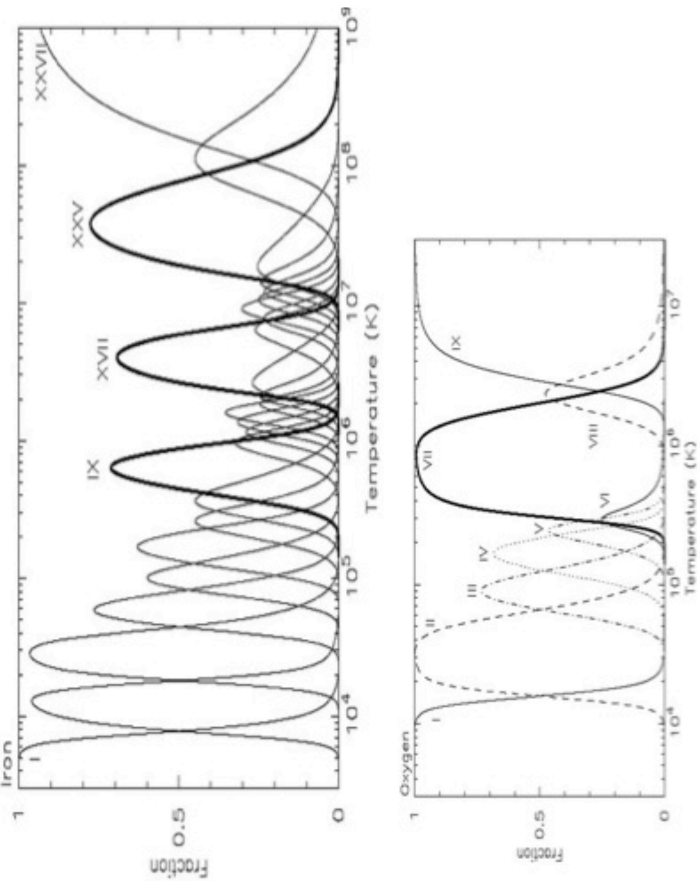
for spectral lines

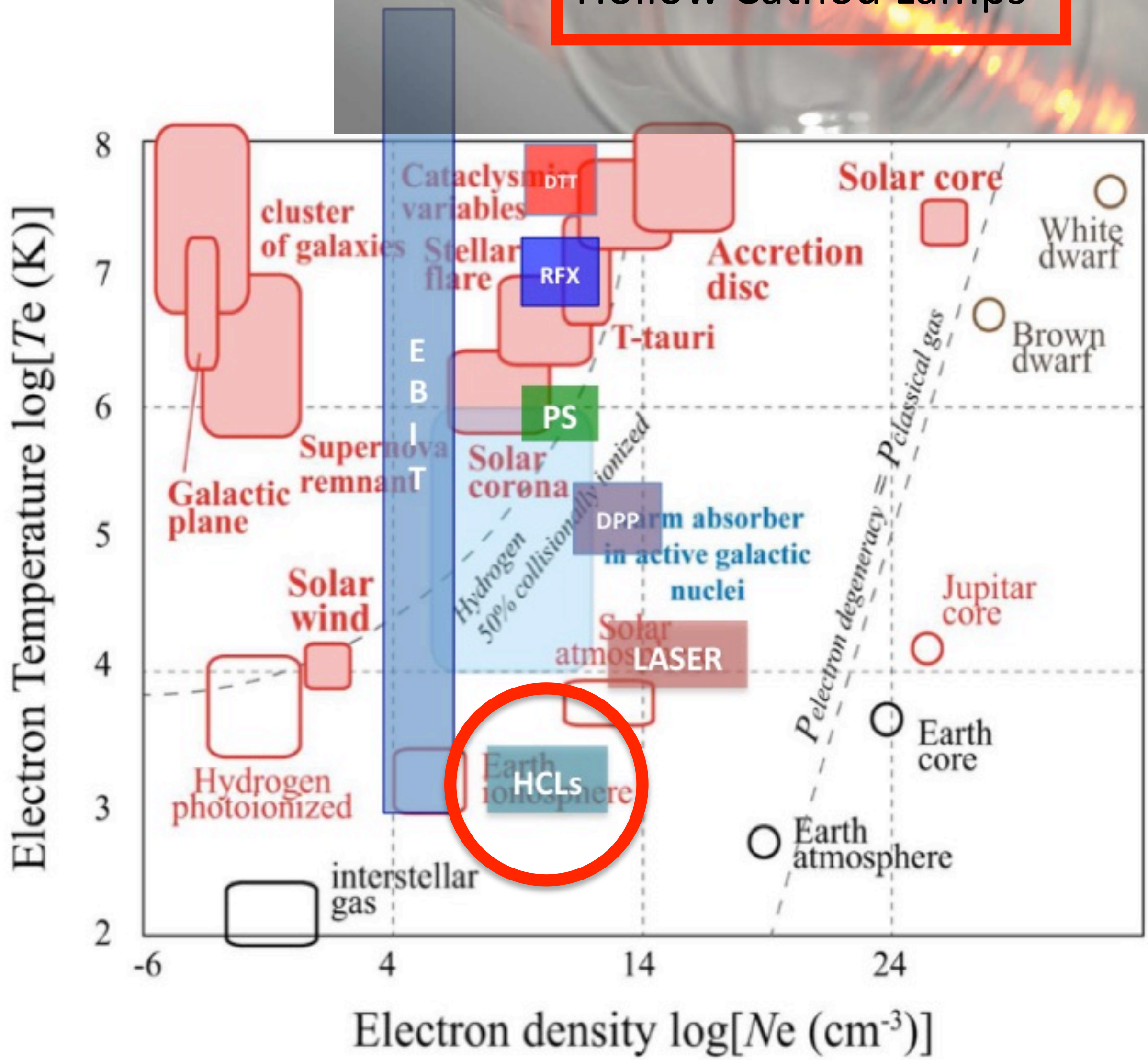
of highly-ionised atoms

from Vacuum-UV to NIR

PLASMA FACILITIES

Available Plasma Facilities

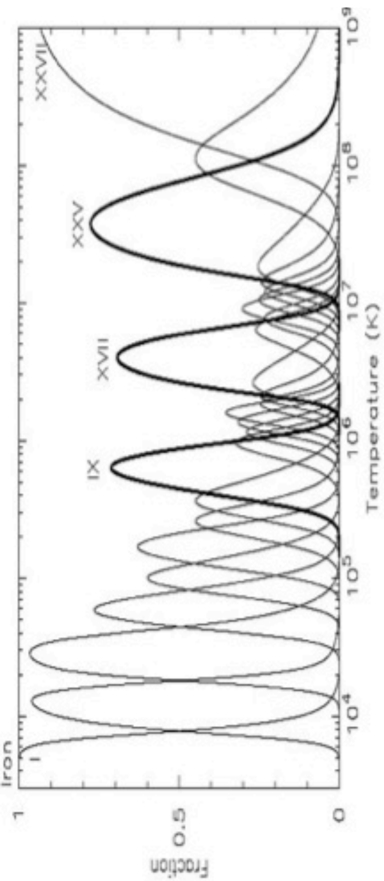


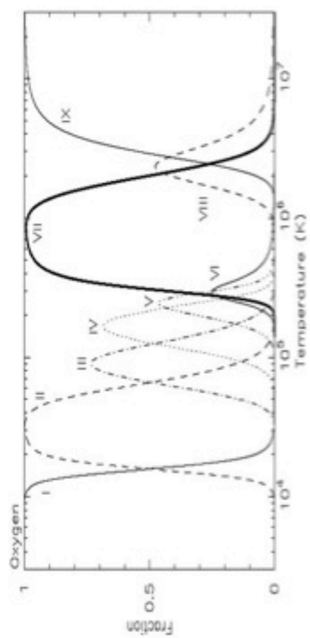


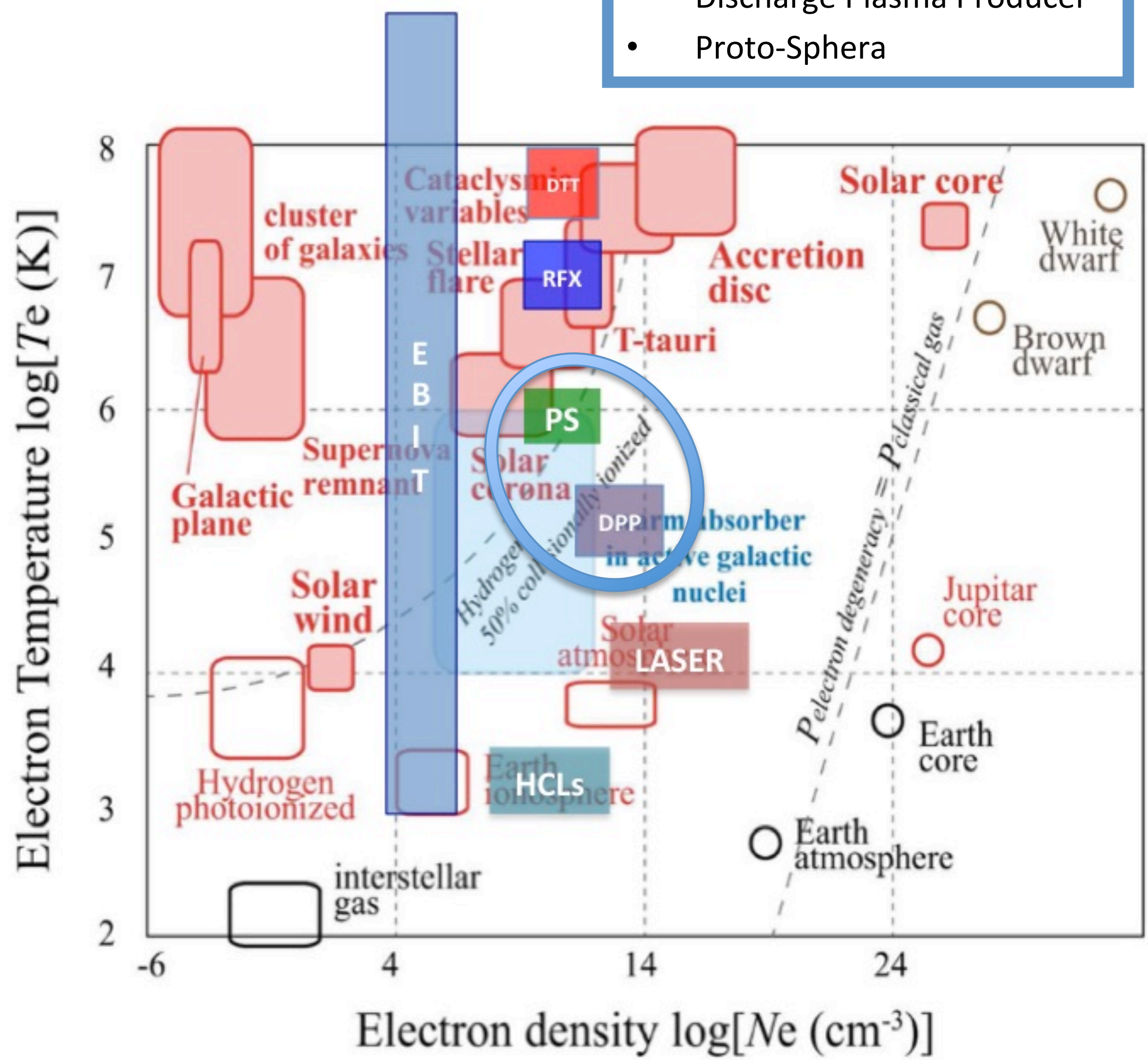
Available Plasma Facilities

ENEA-Frascati Institute

- Discharge Plasma Producer
- Proto-Sphera



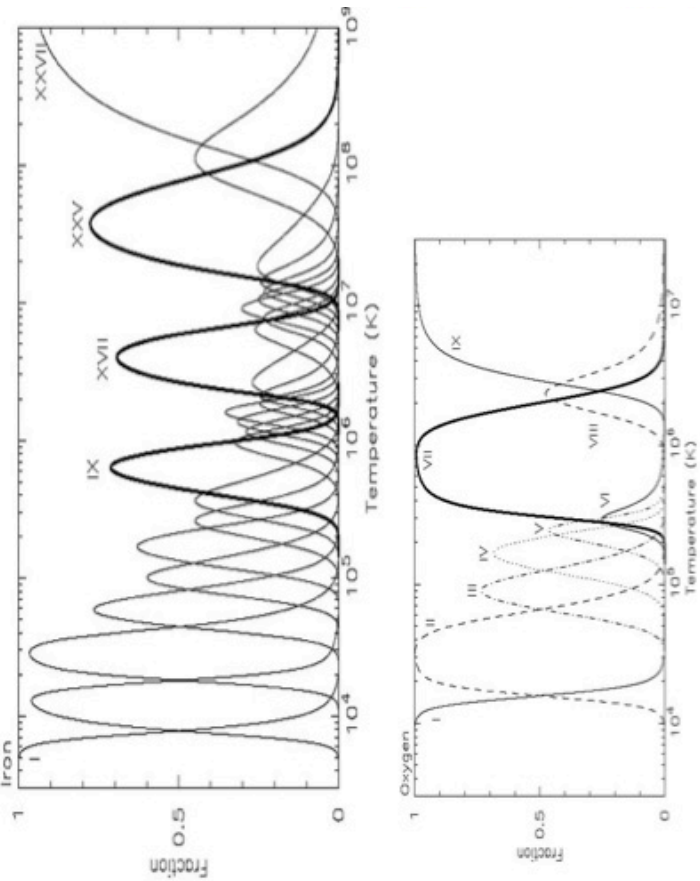


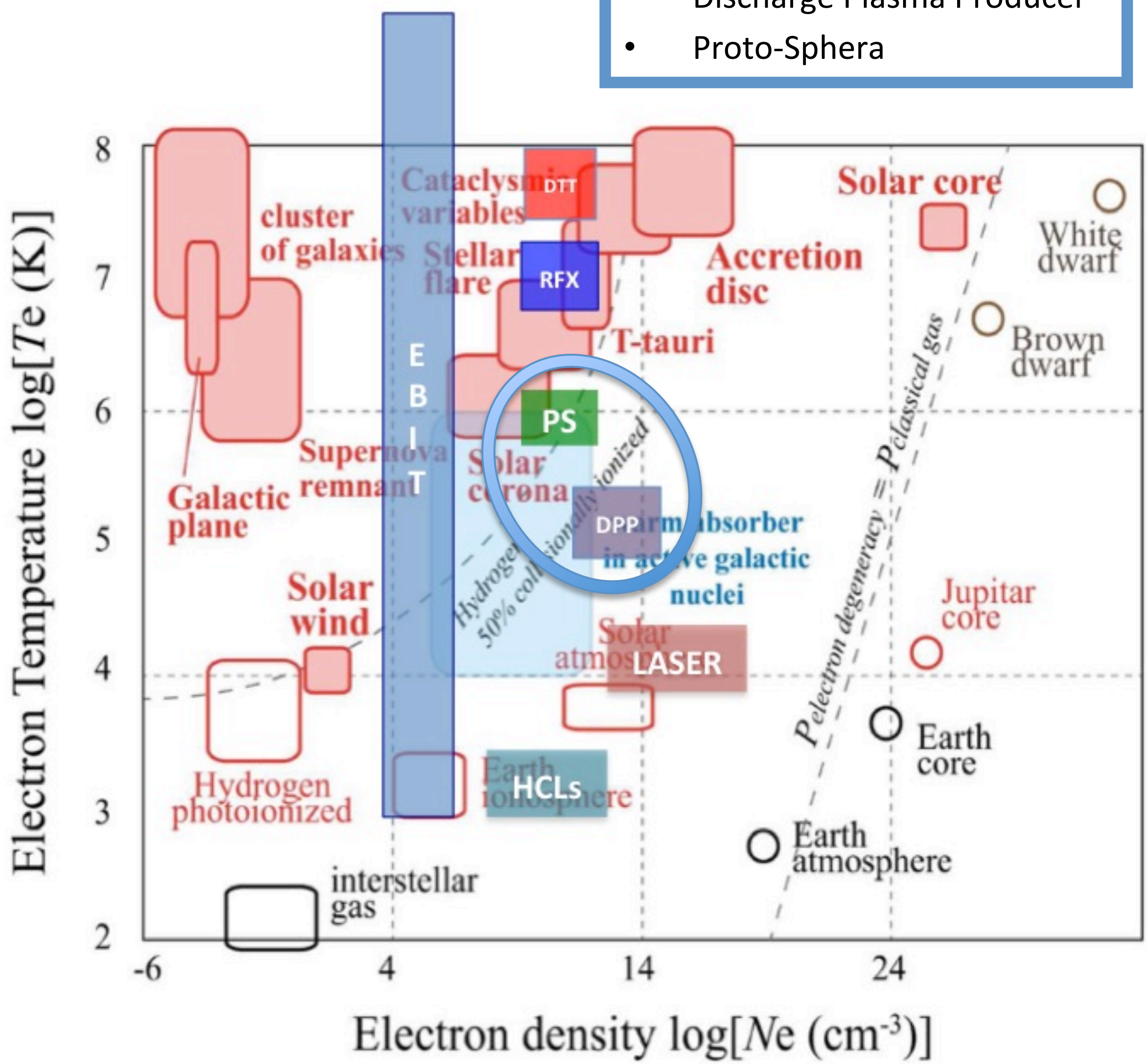


Available Plasma Facilities

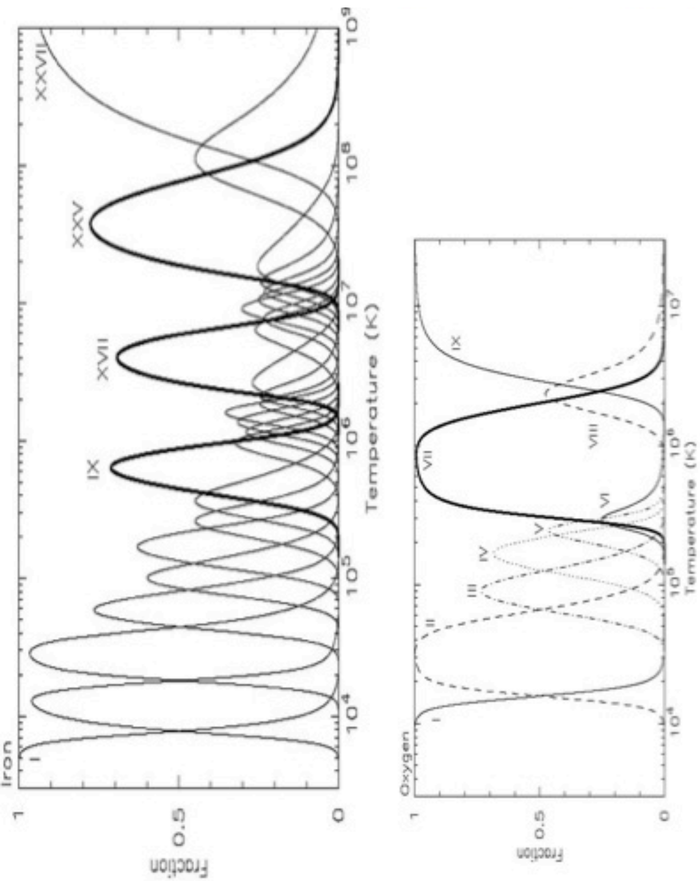
MoU INAF-ENEA
June 20, 2020

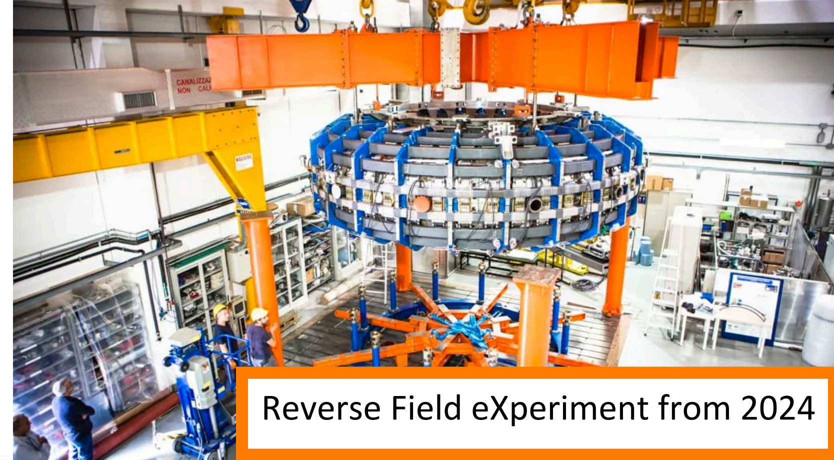
ENEA-Frascati Institute
- Discharge Plasma Producer
- Proto-Sphera

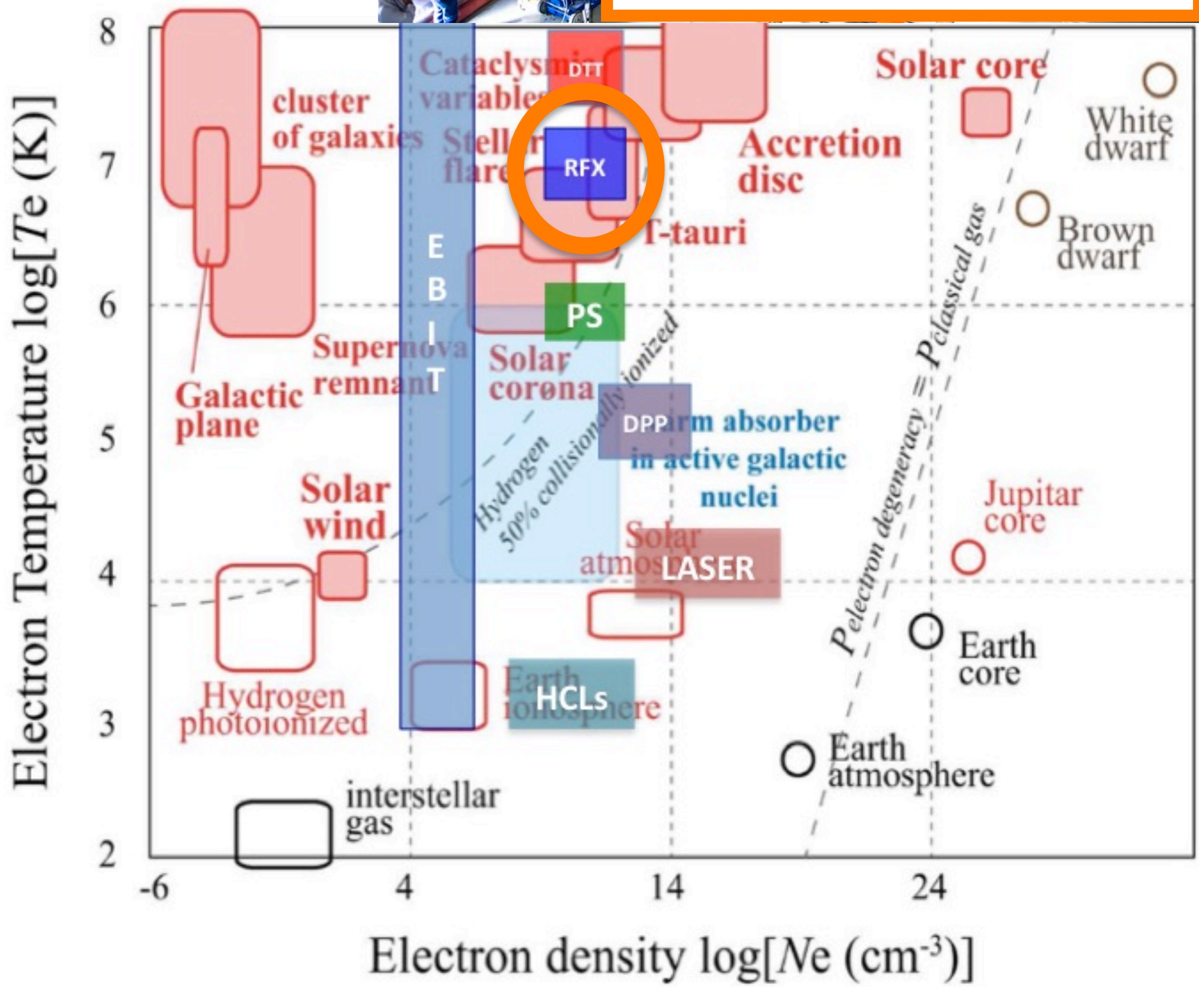




Soon
Plasma Facilities

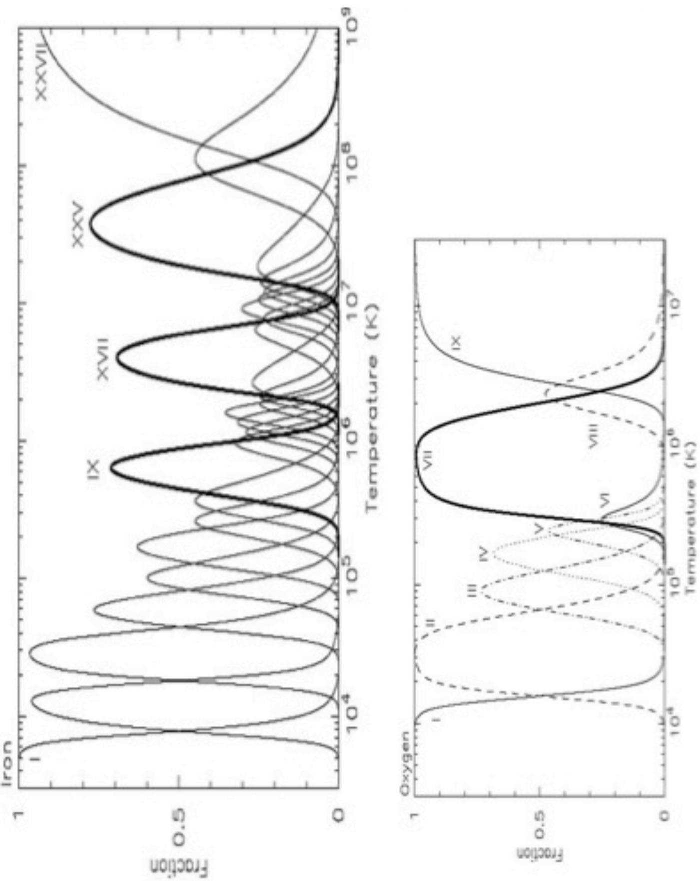


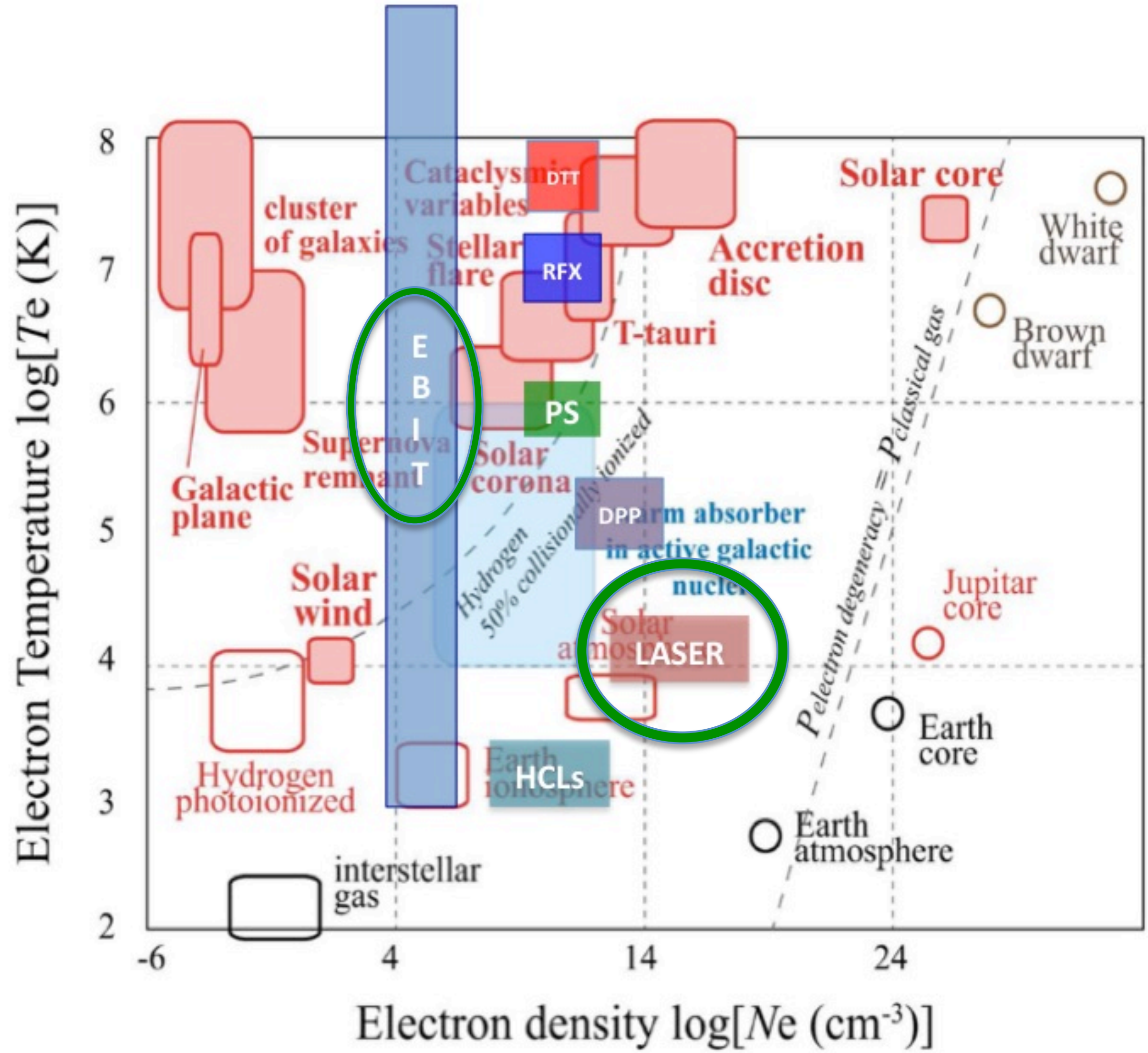




Future
Plasma Facilities

Laser Plasma Producer
Electron Beam Ion Trap





Future
Plasma Facilities

Divertor Tokamak Test Facility